

Documents attached to September 2, 1999, comment letter from the San Joaquin River Group (comment letter no. 0691)

- Comments of the San Joaquin River Tributaries Association et al. presented to the National Marine Fisheries Service re: Designation of Critical Habitat (July 5, 1999)
- Meeting Flow Objectives for the San Joaquin River Agreement 1999-2010, Environmental Impact Statement and Environmental Impact Report (Final) (January 28, 1999)

COMMENTS OF THE
SAN JOAQUIN RIVER TRIBUTARIES ASSOCIATION
AND ITS CONSTITUENT MEMBERS
MERCED IRRIGATION DISTRICT
MODESTO IRRIGATION DISTRICT
OAKDALE IRRIGATION DISTRICT
SOUTH SAN JOAQUIN IRRIGATION DISTRICT
AND TURLOCK IRRIGATION DISTRICT
PRESENTED TO
NATIONAL MARINE FISHERIES SERVICE
RELATING TO THE
DESIGNATION OF CRITICAL HABITAT

July 5, 1999

INTRODUCTION

The San Joaquin Tributaries Association ("SJTA") and its members present their comments to the National Marine Fisheries Service's proposed designation of critical habitat for steelhead in the San Joaquin River and its tributaries.

The SJTA's members, the Merced, Modesto, Oakdale, South San Joaquin and Turlock Irrigation Districts have extensive water rights on rivers tributary to the San Joaquin River. Together, these rivers are a major component of that area designated as the Central Valley ESU. The designation of critical habitat, insofar as it can be determined from the proposed designation, will have significant impacts on each of the members, while providing little benefit to the restoration of native stocks of steelhead. To the extent that a steelhead population is restored, it will likely be at the expense of fall run chinook

salmon, another species proposed for protection which, for many years, has been the major focus of fishery restoration efforts in the San Joaquin, Stanislaus, Tuolumne and Merced Rivers.

1. Occurrence of Steelhead

On January 6, 1997, the SJTA¹ presented comments which demonstrated, based upon monitoring studies and a review of the scientific literature, that naturally-reproducing steelhead are not present in the San Joaquin River or its tributaries. While a small number of steelhead may have been sighted, those steelhead are most likely hatchery strays, and do not represent natural stocks, nor are they suggestive of a self-sustaining population.

In its Final Rule listing steelhead in the Central Valley ESU as threatened, NMFS does little to contradict the evidence presented by the SJTA. For example, NMFS justifies its conclusion that steelhead are present by the following statement:

"Recent observations resulting from monitoring efforts for chinook salmon document steelhead juveniles and/or adults in the lower San Joaquin River, the Stanislaus River, the Tuolumne River and the Merced River. These steelhead appear to represent natural production since hatchery releases in recent years have been made only into the Mokelumne River.

63 Fed.Reg. 13347, 13353. (emphasis added.)

¹ Except as specifically noted, all references to the SJTA are to the SJTA and each of its members.

This statement is indicative of the lack of scientific evidence used by NMFS to justify its listing of steelhead in the San Joaquin River and its tributaries, or to warrant designating those areas as critical habitat for steelhead. Moreover, that statement is entirely consistent with the documented evidence presented by the SJTA that the few steelhead found in the San Joaquin basin are hatchery strays. The lack of scientific evidence is also demonstrated by the fact that NMFS has taken but one sample from those steelhead, and found that

"The single sample we have from the San Joaquin River basin is genetically similar to samples from Coleman Hatchery, Feather River Hatchery, and Deer and Mill Creeks in the Sacramento River." (Id., at 13354.)

Thus, NMFS' own findings bear out the SJTA's contention that steelhead should not be listed in the San Joaquin Basin because there is no scientific evidence of the existence of such species in that region.

The scientific evidence to support a listing of steelhead is inadequate, despite the opportunities that have been available to develop valuable information. There have been one or two anecdotal observations of fish that appeared to be steelhead on the Tuolumne River, but no samples were ever kept, and therefore determining whether those were in fact native steelhead is pure speculation. A simple collection of scales, followed by the genetic testing long advocated by the SJTA,

could have conclusively determined whether the fish were in fact steelhead, and could further have identified the origins of these fish.

Likewise, some large trout have been observed in the Stanislaus River. Such reports are rare despite substantial fishing pressure in the river. The low number of fish caught is even less than one might expect to result due to strays from the nearby hatchery steelhead program in the Mokelumne River. In Oregon where steelhead have been studied more thoroughly, NMFS has received the findings from Oregon Department of Fish and Wildlife that stray steelhead from Alsea Hatchery have been found to compose a high proportion of steelhead catches in many rivers of the central Oregon coast where those fish were not planted.

The foregoing suggests that rainbow trout in the San Joaquin Basin are not unique from those in the Sacramento Basin, and is consistent with the unavoidable recruitment of rainbow from fish stocked in the reservoirs. Rainbow trout derived from Central Valley ancestry have been stocked regularly in all San Joaquin tributaries, particularly in reservoirs. It has been widely demonstrated, and is common knowledge among fish management biologists that some trout stocked in reservoirs pass downstream, either through the turbines or over the spill. The term "tailwater fishery" is well known by biologists, and is

used to refer to fisheries that occur within limited distances downstream of reservoirs. For example, the popular fishery for resident rainbow trout within the first 4 miles below Goodwin Dam on the Stanislaus River is a typical tailwater fishery. These tailwater fisheries are supported by the release of cool hypolimnetic water atypical of natural river conditions, and by a supply of fish that drift downstream from the reservoir above. Given that suitable spawning habitat for rainbow/steelhead is rare or absent below dams in the San Joaquin, and that spawning of rainbow/steelhead below these dams has not been observed, recruitment from upstream is their most likely source.

The simple solution, as noted above, would have been to conduct genetic testing. However, the SJTA's efforts to conduct that testing were resisted by state regulators, and the SJTA was not allowed to undertake the genetic testing, even at its own expense, that would have conclusively answered those questions.

2. Consideration of Rainbow Trout

Communication with NMFS's staff members suggests that NMFS considers all O.mykiss that have physical access to the ocean (including resident rainbow trout) to potentially be steelhead (personal communications between Jennifer Vick and Chris Mobley, Dennis Smith, and Steven Edmundson, MNFS). Accordingly, these comments touch briefly on rainbow trout issues. However, it is the position of SJTA that because rainbow trout are not a

protected species under the ESA (See 63 Fed.Reg. 13347, 13369:

"At this time, NMFS is listing only anadromous life forms of *O.mykiss.*"), it is improper for NMFS to consider critical habitat for rainbow trout in this proceeding.

3. Critical Habitat

The Endangered Species Act defines critical habitat as follows:

The term critical habitat for a threatened or endangered species means—

- (i) the specific areas within the geographical area occupied by the species, at the time it is listed. .
. on which are found those physical and biological features
 - (I) essential to the conservation of the species and
 - (II) which may require management considerations or protections and
- (ii) the specific areas outside the geographical area occupied by the species at the tie it is listed. . .
upon a determination by the Secretary that such areas are essential for the conservation of the species.

(ESA, § 3(5) (A) .)

Thus, the characteristics of critical habitat depend on whether the species was present at the time of the listing. The overwhelming evidence, as noted above, is that there are no steelhead present in the San Joaquin system. Thus, the appropriate test for designating critical habitat is whether

there are "specific areas" which are "essential for the conservation of the species." As these comments will amply demonstrate, the conditions in the San Joaquin system are not "essential for the conservation" of steelhead, and should not be designated. Alternatively, in the event that NMFS seeks to designate critical habitat under subsection (i) on the assumption that steelhead were present at the time of the listing, the following comments will demonstrate that the system does not have "those physical and biological features" which are essential to the conservation of steelhead. Thus, in either case, the designation of the San Joaquin River and its tributaries is in appropriate under the provisions of the ESA.

In addition to the foregoing, NMFS proposed listing fails to meet the requirements of the ESA in that it fails to designate "specific areas," as required by Section 3 (5) (A).

The following addresses each of those points.

- (a) The San Joaquin River and its tributaries do not have the required physical and biological features, and are not areas essential for the conservation of the species.

The Merced, Tuolumne and Stanislaus Rivers do not have the physical and biological features required for steelhead, and do not provide the type of habitat that will support a steelhead population. While there are a great many factors that lead to the conclusion that those rivers are not essential to the

conservation of steelhead (See below; and see the comments of the individual tributaries attached hereto)insufficiency of those rivers for steelhead habitat, the overarching factor is that no matter what steps are taken, the lower reaches of the rivers simply do not have perennial attributes suitable for steelhead spawning, nor do they have sufficient gradient to create or sustain the combination of pool-riffle habitat to which steelhead are adapted. Bisson et al. (1988) have shown from studies across a large number of streams in western Washington that steelhead occur most in riffles and "deep pools with relatively high velocities in the center of the channel." Further, Bisson et al. (1988) concluded, "Steelhead possessed a more cylindrical body shape with short median fins and relatively large paired fins, attributes that appear well adapted to holding a position in swift water."

Steelhead seek a high-elevation habitat marked by moderate gradient and narrow channels, characteristics that will never be present in the lower reaches of the San Joaquin River mainstem or on the Merced, Tuolumne or Stanislaus Rivers below the dams on the lower reaches of each such river.

Even if each tributary maximizes spawning and rearing habitat, increases cover, reduces water temperatures during critical period, the limiting factor is lack of gradient and less than optimum channel size.

Could steelhead be restored to portions of the rivers having characteristics favorable to steelhead? The answer is "probably not." The essential element to such an effort would be construction of fish passages that would allow steelhead to reach areas upstream of the dams on each of the rivers. Yet, construction of such facilities is not likely to succeed in that respect. First, it would be extremely expensive and complicated to design, build and maintain a fish passage that would attract steelhead and provide the necessary habitat for the fish as they transit through the facility. Ignoring for a moment the significant water needs such a facility would require, the critical factors would include adequate substrate, food supply, cover and protection from predators. Among the problems migrating steelhead would face are: (1) attraction to the bypass facility, (2) migration delays; and (3) mortality and injury in that bypass. Even allowing the steelhead to navigate around the dams, however, is unlikely to produce the desired results. Once through the facility much of the habitat between dams has been converted to reservoirs. The still waters in those reservoirs would likely be difficult for steelhead to traverse due to lack of directional signals normally available from flowing currents. Finally, if the steelhead were to find their way to the upper reaches of the river to spawn, the likely result is that when

the young "smoltify," their point of outward migration will not be the ocean, but the reservoirs behind the dams.

It should be clear that since natural production of steelhead in the Central Valley has been confined to the Sacramento Basin for roughly one century, attempts to establish steelhead in the San Joaquin are clearly not essential to preservation of the species. The absence of steelhead in the San Joaquin River has had nothing to do with population trends of steelhead in the Sacramento River, especially in the last 50 years.

Thus, for the reasons set forth, designation of the lower reaches of the San Joaquin River and its tributaries, as well as areas above the major dams on those rivers, as critical habitat for steelhead is inappropriate.

Even though the SJTA members believe that such designation is inappropriate, each has attempted to address in greater detail the issues raised in the Notice. Their individualized responses to the Notice, addressing conditions particular to each tributary, are attached hereto, and are incorporated herein by this reference.

However, there is one additional matter of common concern that should be noted here, though addressed further in the attachments. NMFS' proposed 60 degree rearing standard is inappropriate for these rivers. While that standard may be

appropriate in the Pacific Northwest where it was developed, experiments with Central Valley stocks indicate that the preferred rearing temperatures range from 60 degrees to 68 degrees.

For the reasons set forth above, and as described in detail in the attachments hereto, the Stanislaus, Tuolumne, Merced and San Joaquin Rivers do not exhibit the physical or biological features of Steelhead habitat, nor are those areas essential to the conservation of that species.

In summary, the following are the major problems associated with designating the Stanislaus, Tuolumne, Merced and San Joaquin Rivers as critical habitat:

- There is no scientific evidence documenting the current use of the Stanislaus, Tuolumne, Merced and San Joaquin Rivers by native steelhead stocks.
- Conditions in each of those rivers are not suitable for supporting a steelhead population, because those areas do not possess the required characteristics of high elevation, moderate gradient and channels morphologically capable of avoiding scour of steelhead spawning gravels during bankfull flow events.
- Rainbow trout found in the lower reaches of the rivers are of unknown origins; they are most likely fish planted in upstream reservoirs that have found their way into downstream areas.
- These rivers have been managed for chinook salmon, and those management efforts have resulted in recent increases in salmon populations. Managing for a species that will compete with chinook salmon for water resources may be counter-productive.

- Because these rivers are not currently occupied by naturally reproducing steelhead, they should not be considered essential for the conservation of the species. NMFS should focus its efforts on those areas occupied by viable steelhead populations or where access to middle and upper watershed spawning and rearing habitats is available, especially in light of NMFS' stated opposition to hatchery fish.
- (b) The proposed designation fails to designate "the specific areas" essential to the conservation of the species.

Section 3(5)(A) of the Act defines critical habitat as:

- (i) the **specific areas** within the geographical area occupied by the species . . . on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management consideration or protection; and
- (ii) **specific areas** outside the geographical area occupied by the species at the time it is listed . . . upon a determination by the Secretary that such areas are essential for the conservation of the species.

The requirement that "specific areas" be identified is reinforced in subsection (c), which provides: "Except in those circumstances determined by the Secretary, critical habitat shall not include the entire geographical area which can be occupied by the threatened or endangered species." (emphasis added.)

NMFS seeks comments on the proposed designation of critical habitat. However, the scope of the proposed designation is so broad that adequate comment is virtually impossible. NMFS seeks

comment on matters relating to substrate, cover/shelter, food, and riparian vegetation throughout the entire San Joaquin River and its tributaries. In order to do an adequate job of responding to this request, the SJTA would have to provide comments on each of those subjects for well over 100 miles of river. With regard to the issue of riparian vegetation, not only is the entire river system potential critical habitat, but adjacent areas, to an unspecified width, are subject to designation. As a result, meaningful comment covering the entire range of the San Joaquin Basin is virtually impossible. SJTA believes that because the proposed rule is overly broad, and does not comply with the requirements of Section 3(5)(A), that it is unlawful.

NMFS' notice also fails to comply with the requirements of the Administrative Procedure Act (5 U.S.C. § 553; hereinafter the "APA"). The APA requires an agency to provide notice of a proposed rule and an opportunity for comment (5 U.S.C. § 553(b) - (c)). Notice of a proposed rule must include sufficient detail on its content and basis in law and evidence to allow for meaningful and informed comment. (American Medical Association v. Reno, 57 F.3d 1129, 1132 (U.S. App. D.C. 1995.)) In order to meet that burden, the proposed rule must provide sufficient information to permit informed adversarial critique. (Home Box

Office, Inc. v. FCC, 567 F.2d 9, 55 (D.C. Cir. 1977.) NMFS' designation of all areas within the San Joaquin River and its tributaries, plus an amorphous reference to an undefined riparian corridor fall woefully short of the requirements of the APA.

4. Interspecies Competition

Full support of steelhead would be at the expense of chinook salmon for two reasons. First, steelhead rear in freshwater year round, so it is probable their need for water in mid- and late-summer would detract from use of that water to benefit chinook in the fall, especially when reservoirs are low and there is not a sufficient cold water pool. It would also detract from the spring pulse flow. Thus, any water used in the summer for steelhead will impact water made available for fall run chinook salmon. Second, steelhead rearing would be constrained to areas that overlap with chinook rearing because age 1 and 2 steelhead juveniles are well known to prey on chinook eggs and fry in areas of habitat overlap.

5. NMFS has impermissibly ignored the economic impacts of its proposed designation

The proposed designation of critical habitat fails to comply with the provisions of Section 4 (b) of the Act. That section provides:

"The Secretary shall designate critical habitat . . . on the basis of the best scientific data available and after taking into consideration the economic impact, and any other relevant impact, of specifying any particular area as critical habitat."

NMFS takes the position that because "virtually all 'adverse modification' determinations pertaining to critical habitat would also result in 'jeopardy' conclusions under ESA Section 7 consultations (i.e., as a result of the species already being listed), the designation of critical habitat is not expected to result in significant incremental restrictions on Federal agency activities." (64 Fed.Reg. 5740, 5747.) As a result, critical habitat designation will not result in additional significant economic impacts, according to NMFS.

That conclusion has two significant flaws: (1) it ignores the clear mandate of Section 4 (b), and (2) it fails to take into consideration the impacts that will be felt in areas designated as critical habitat in which steelhead are not currently present.

As noted above, in considering the designation of critical habitat, the Secretary **shall** consider the economic impacts. NMFS' position, as set forth in the proposed designation, makes no sense. NMFS' argument is that once a species is listed, designation of critical habitat carries no greater burden, and, therefore, economic impacts need not be considered. If that is true, then Section 4 (b) is meaningless. And since economic

issues cannot be considered in the listing decision, following NMFS' approach, economic issues then can be totally ignored. This is totally contrary to the clear mandate in the Act that economic impacts be considered in designating critical habitat.

NMFS' position would also preclude consideration of economic impacts in those areas which would be included within the critical habitat designation, but outside the present range of steelhead. If, as these commenting parties contend, there are no existing populations of native steelhead in the San Joaquin River and its tributaries, then the designation of critical habitat would have impacts beyond those of the act of listing itself, and must be considered.

6. NMFS has failed to comply with the Regulatory Flexibility Act.

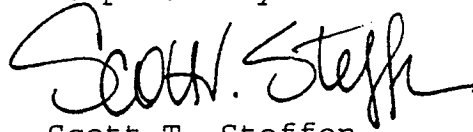
For the same reasons set forth in the preceding paragraph, NMFS has failed to comply with the provisions of the Regulatory Flexibility Act (5 U.S.C. § 603, hereinafter the "RFA"), which require consideration of the impacts of the designation on small businesses. Whether or not the designation of critical habitat is, in fact, beyond the current range of the steelhead, the impacts on small businesses must be considered. NMFS has specifically declined to undertake that analysis, in total contravention of the clear mandate of the RFA.

CONCLUSION

As is demonstrated by the foregoing, there is no basis for the designation of the San Joaquin River or its tributaries as critical habitat for steelhead. Those areas are not essential for the conservation of steelhead, and they lack the biological and physical features that would make them essential for conservation of steelhead.

Dated: July 2, 1999.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Scott T. Steffen". The signature is fluid and cursive, with the first name "Scott" and last name "Steffen" clearly distinguishable.

Scott T. Steffen
On behalf of the
San Joaquin Tributaries
Association
and the Merced, Modesto,
Oakdale, South San
Joaquin and Turlock
Irrigation Districts

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EVALUATION OF THE TUOLUMNE RIVER AS POTENTIAL CRITICAL HABITAT FOR STEELHEAD

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EVALUATION OF THE TUOLUMNE RIVER AS POTENTIAL
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1. **Executive Summary**

Based on the information summarized in Sections 2 through 8 below, we have concluded the following:

- Water temperature likely limited steelhead spawning and rearing distribution under historical (i.e., pre-dam) conditions. Although steelhead presumably occurred in the Tuolumne River watershed in pre-dam times, their distribution was likely limited to middle and upper watershed areas during most years due to low flow conditions and high temperatures in the late summer and early fall. It is, therefore, unlikely that steelhead historically spawned or reared in significant numbers downstream of La Grange Dam.
- Under current conditions, water temperatures in the Tuolumne River potentially limit steelhead habitat in the Tuolumne River. Suitable summer/fall rearing temperatures as defined by NMFS' 60°F criterion currently occur in the Tuolumne River in a short reach downstream of La Grange Dam in wetter years.
- NMFS evaluation temperature for steelhead rearing (60°F) may be low for the Central Valley Steelhead ESU. Experiments evaluating Central Valley stocks indicate that preferred rearing temperatures range from 60° to 68°F, with the lethal critical thermal maximum occurring at 80°F. Myrick (1998) suggests that 68°F is a more suitable criterion for Central Valley steelhead. This suggestion is consistent with field observations in various drainages.
- The Mokelumne River provides a potential steelhead source population to recolonize the Tuolumne River. This population consists primarily of hatchery stock, which were introduced from the Eel River, outside the Central Valley ESU. Hatchery stocks are not included in the listing.
- Rainbow trout are known to occur in the lower Tuolumne River but their genetic origin is unknown. These trout may originate from hatchery stocks that are planted in reservoirs in the basin and may not be native to the San Joaquin Basin. However, resident rainbow trout are not listed.
- NMFS has not assessed whether the Tuolumne River is essential for the conservation of the Central Valley steelhead ESU. Our assessment indicates that the Tuolumne River is not essential for the conservation of such species and does not contain physical or biological features that are essential to the conservation of the species.
- Should a steelhead population become established in the Tuolumne River downstream of La Grange Dam, interspecies interactions between steelhead and fall chinook may adversely affect the Tuolumne River fall chinook population. Major interspecies interactions that should be considered include: (1) competition for spawning gravel and potential for redd superimposition, (2) competition for rearing habitat, (3) competition for

food resources, and (4) predation by steelhead on fall chinook salmon eggs, fry, and juveniles.

- The Tuolumne River downstream of La Grange Dam may provide limited spawning and rearing habitats suitable for steelhead. The extent of these habitats and their capacity to support a self-sustaining steelhead population have not been evaluated. In the Mokelumne River, lack of suitable rearing substrate is considered to limit steelhead production is considered to make recovery of a sustainable steelhead population difficult, if not impossible.

2. Description of the Central Valley ESU, and Steelhead

The Central Valley steelhead ESU, as presently defined, includes the Sacramento and San Joaquin rivers and their tributaries (excluding the mainstem San Joaquin River upstream of the Merced River confluence). San Francisco Bay and San Pablo Bay are not part of this ESU.

Steelhead is the term commonly used for the anadromous life history form of rainbow trout (*Oncorhynchus mykiss*). Steelhead exhibit highly variable life history patterns throughout their range, but are broadly categorized into winter and summer reproductive ecotypes. Winter steelhead, the most widespread reproductive ecotype, become sexually mature in the ocean, enter spawning streams in summer, fall or winter, and spawn a few months later in winter or late spring (Meehan and Bjornn 1991, Behnke 1992). Summer steelhead generally enter fresh water in spring and summer as sexually immature fish, hold over for 8-10 months, and spawn the following spring. Adults may return to the ocean after spawning and return to freshwater to spawn in subsequent years. Juveniles remain in fresh water for 2-4 years before immigrating to the ocean. Juvenile emigration typically occurs from April through June. Only winter-run steelhead stocks are currently present in Central Valley streams (McEwan and Jackson 1996). In the Sacramento River, steelhead generally emigrate as 2-year olds during spring and early summer months. Emigration appears to be more closely associated with size than age, with 6-8 inches (152-203 mm) being most common for downstream migrants. Downstream migration in unregulated streams has been correlated with spring freshets (Reynolds et al. 1993). Steelhead life history and habitat requirements are discussed in more detail in Appendix A.

Anadromous v. Resident Forms of O. mykiss

The relationship between anadromous and resident life history forms of *O. mykiss* is poorly understood, but evidence suggests that the two forms are capable of interbreeding and that, under some conditions, either life history form can produce offspring that exhibit the alternate form (i.e., resident rainbow trout can produce anadromous progeny and vice versa) (Shapovalov and Taft 1954; Burgner et al. 1992, as cited in NMFS 1999; Hallock 1989, as cited in Cramer et al. 1995). The fact that little to no genetic differentiation has been found between resident and anadromous life history forms inhabiting the same basin supports this hypothesis (Busby et al. 1993, as cited in Cramer et al. 1995; Nielsen 1994, as cited in McEwan and Jackson 1996).

Only anadromous forms of *O. mykiss* were listed. The National Marine Fisheries Service (NMFS) considered including resident *O. mykiss* in listed steelhead ESUs in certain cases,

including (1) where resident *O. mykiss* have the opportunity to interbreed with anadromous fish below natural or artificial barriers or (2) where resident fish of native lineage once had the ability to interbreed with anadromous fish but no longer do because they are currently above artificial barriers and are considered essential for the recovery of the ESU (NMFS 1998, p. 13350). The U.S. Fish and Wildlife Service (USFWS), which has authority under the Endangered Species Act (ESA) over resident fish, however, concluded that behavioral forms of *O. mykiss* can be regarded as separate Distinct Population Segments (the USFWS version of an ESU) and that lacking evidence that resident rainbow trout need ESA protection, only anadromous forms should be included in the ESU and listed under the ESA (NMFS 1998, p. 13351). The USFWS also did not believe that steelhead recovery would rely on the intermittent exchange of genetic material between resident and anadromous forms (NMFS 1998, p. 13351). In the final rule, the listing includes only the anadromous life history form of *O. mykiss* (NMFS 1998, p. 13369).

Accordingly, NMFS request for comments on designation of critical habitat for resident rainbow trout is improper.

From this information, it seems that resident rainbow trout are not protected under the ESA and are not included in the ESU. NMFS, however, considers all *O. mykiss* that have physical access to the ocean (including resident rainbow trout) to potentially be steelhead (Chris Mobley, Dennis Smith, and Steven Edmundson, NMFS, personal communication) and will treat these fish as steelhead because (1) resident fish can produce anadromous offspring, and (2) it is difficult or impossible to distinguish between juveniles of the different life history forms. NMFS considers juvenile *O. mykiss* smaller than 8 inches (209 mm) and adult *O. mykiss* larger than 16 inches (406 mm) to be steelhead (Dennis Smith, NMFS, personal communication). NMFS does not yet have a written policy regarding this position or clarifying their relationship with the USFWS in protecting resident rainbow trout and anadromous steelhead.

Adult resident rainbow trout occurring in Central Valley Rivers are often larger than Central Valley steelhead. Several sources indicate resident trout in the Central Valley commonly exceed 16 inches (406 mm) in length. Cramer et al. (1995) reported that resident rainbow trout in Central Valley rivers grow to sizes of more than 20 inches (508 mm). Hallock et al. (1961) noted that resident trout observed in the Upper Sacramento River upstream of the Feather River were 14-20 inches (356-508 mm) in length. Also, at Coleman National Fish Hatchery, the USFWS found about 15 percent overlap in size distribution between resident and anadromous fish at a length of 22.8 inches (579 mm) (Cramer et al. 1995). NMFS's size criterion for steelhead, therefore, has significant overlap with resident rainbow trout occurring in Central Valley rivers, and many resident adult trout will be considered to be steelhead.

3. Historical and Current Use of Tuolumne River by Steelhead and Rainbow Trout

3.1 Occurrence of Steelhead in the Tuolumne River

In the final rule, NMFS states that "[r]ecent observations resulting from monitoring efforts for fall chinook salmon document steelhead juveniles and/or adults in the lower San Joaquin River, the Stanislaus River, the Tuolumne River, and the Merced River" (NMFS 1998, p. 13353). Data

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supporting this statement, however, are not cited or provided, and we are aware of only two recent observations of potential steelhead in the Tuolumne River. These occurred in 1983 and 1999, and neither was corroborated. In addition, a later statement in the listing indicates that evidence of steelhead occurrence in only the Stanislaus and Merced Rivers was available at the time of the final rule, as follows:

NMFS also stated that newly compiled information exists on the presence of steelhead in streams in the San Joaquin River Basin. This information indicates that steelhead smelts occur in the lower San Joaquin and Stanislaus Rivers and adult steelhead occur in the Stanislaus and Merced Rivers (NMFS 1998, p. 13368).

The historical distribution of steelhead in the San Joaquin Basin, including the Tuolumne River, is poorly known. The only report of the historical occurrence of steelhead in the Tuolumne River is provided by California Department of Fish Game (CDFG) salmon escapement counts in the early 1940s. These counts were conducted at Dennett Dam (RM 16.2) near Modesto and reported 66 steelhead in 1940 and five in 1942 (CDFG, unpublished data).

Based on their life history and habitat requirements, steelhead would be expected to have spawned and reared at least in the middle and upper Tuolumne River watershed prior to the construction of Wheaton Dam in 1871. Steelhead juvenile life history and rearing habitat requirements are similar to those of spring chinook salmon in that juveniles of both species oversummer in fresh water and, therefore, require cool riverine water temperatures throughout the year. Spring chinook have been documented to have occurred in the Tuolumne River basin prior to the construction of large dams. Steelhead distribution in the Tuolumne River watershed likely overlapped with that of spring chinook salmon, but steelhead likely ascended farther upstream in the watershed. Water conditions in the Lower Tuolumne River make it highly unlikely that steelhead spawned or reared in that reach (see detailed discussion of those conditions in Section 4, below).

In addition, despite extensive field surveys, resource agencies and the Districts have not observed or trapped any fish confirmed to be steelhead, although rainbow trout have been recorded. Field surveys have included biweekly seining from January through May throughout the river, winter and spring trapping using fyke nets or rotary screw traps, snorkeling, and electrofishing (Appendix C). In 1997, 1998 and 1999, CDFG found *O. mykiss* during their the fall chinook salmon carcass surveys and outmigrant monitoring (see Appendix D). In 1997, CDFG encountered three carcasses; the two that were measured were 16 inches (410 mm) and 18.9 inches (480 mm) fork length. In 1998, approximately ten carcasses were encountered. These carcasses were not measured or photographed, but CDFG staff estimated that they were approximately 10 inches (250 mm) fork length. CDFG also collected heads from three of these carcasses. The otoliths from these heads could be used to determine whether these fish were anadromous, but to our knowledge there are no current plans to do so. CDFG does not feel that the carcasses observed in 1998 were steelhead (Tim Heyne, CDFG, personal communication). In 1999, CDFG captured what they believe to be a single steelhead smolt in their rotary screw trap at Grayson River Ranch (RM 5.1) (Tim Heyne, CDFG, personal communication). However,

neither that fish, nor any samples from which genetic testing could be concluded, were kept, and confirmation of that fish as steelhead is not possible.

3.2 Occurrence of Rainbow Trout in the Tuolumne River

Monitoring conducted primarily for fall chinook salmon in the Tuolumne River has documented the occurrence of rainbow trout. Observations of *O. mykiss* in the Tuolumne River in the 18-year period from 1981 to the present are shown in Appendix D. Trout observations have mostly been restricted to the upstream, cooler reaches of the Tuolumne River within 10 miles (16 km) downstream of the La Grange Dam. Most observations have been of age 0+ trout seen in early spring and summer during seining, snorkeling, and stranding surveys. Fewer age 1+ trout have been observed. The largest numbers of trout observed were approximately 380 age 0+ and 1+ (no information on size was collected) seen during July 1996 in snorkel surveys between RM 48.0 and 50.7 by CDFG, and 65 fish ranging from 100 to 350 mm in size seen during an August 1986 snorkel survey between RM 48.0 and 51.6. No trout have been observed downstream of RM 38.5 despite seining that has occurred throughout the Tuolumne River to its confluence with the mainstem San Joaquin River.

3.3 Genetic Origin of Steelhead Source Populations and Rainbow Trout Occurring in the Tuolumne River Downstream of La Grange Dam

The listed Central Valley steelhead ESU includes only naturally spawned populations residing below natural and artificial barriers and does not include Nimbus Hatchery and Mokelumne Hatchery stocks (which were imported from the Eel River). In addition, the final rule states that resident fish "that are derived from the introduction of non-native rainbow trout" are not included in any ESU (NMFS 1998, p. 13350).

Strays from the Mokelumne River, which is located approximately 40 miles (64 km) to the north of the Tuolumne River, provide a potential source of any steelhead which might populate the Tuolumne River. The Mokelumne River Hatchery and has experienced significant introductions of out-of-basin stocks. The majority these steelhead are winter-run steelhead of Eel River (coastal California) origin. Other stocks released into the Mokelumne River were received from the Feather River and Coleman (located on Battle Creek, a tributary to the Sacramento River) hatcheries. The Feather River Hatchery stock originates from Feather and Eel river stocks, and Coleman Hatchery stock originates from Battle Creek and Sacramento River steelhead stock. Due to these extensive out-of-basin transfers, it is likely that any steelhead found in the Tuolumne River will not be of Central Valley origin.

The origin of the rainbow trout found in the lower Tuolumne River is not known. These trout may originate from spills from La Grange Reservoir, Turlock Reservoir, Modesto Reservoir, and/or Don Pedro Reservoir. Rainbow trout have been stocked in the last three of these reservoirs. The likelihood that rainbow trout found below La Grange Dam originated in the reservoirs above the dam is buttressed by the fact that until recently the river was managed with low summer flows to preclude the establishment of rainbow trout downstream of La Grange Dam, as a significant rainbow trout population was deemed to be inconsistent with the efforts to

maintain chinook salmon populations in the lower Tuolumne River. If trout in the Tuolumne River are the result of introductions of non-native trout, they are excluded from the ESU. This issue, however, cannot be resolved without detailed genetic evaluation. In June 1997, CDFG attempted to collect rainbow trout from the Tuolumne River for genetic analysis. Despite electrofishing and seining at two sites near the town of La Grange (approximately 1.7 miles downstream of La Grange Dam), CDEG was able to collect only two juvenile rainbow trout (both less than 100 mm in length) (McEwan 1997). CDFG is currently attempting to obtain funding to conduct genetic analysis of rainbow trout throughout the Central Valley both upstream and downstream of major dams (Dennis McEwan, CDFG, personal communication).

4. Quality and Extent of Steelhead Habitat Present in the Tuolumne River

4.1 Background

The Tuolumne River drains a 1,960-square mile watershed on the western slope of the Sierra Nevada Range. The river originates in Yosemite National Park and flows southwest to its confluence with the San Joaquin River (at San Joaquin River RM 83.7), approximately 10 miles west of the city of Modesto. Its upper watershed is characterized by deep canyons and mountainous terrain. Downstream of the Sierra Nevada mountains and foothills, the river flows through a gently sloping alluvial valley. Land uses adjacent to the river in the alluvial valley consist primarily of agriculture, industry (mining), and urban development.

Flow in the Tuolumne River is regulated by several dams (Figure 1). The Districts' La Grange Dam (RM 52.2) was constructed in 1893 and replaced Wheaton Dam, which was originally constructed at the same site in 1871. La Grange Dam has only limited storage capacity and diverts flow into Modesto Irrigation District's canal to the north of the river and Turlock Irrigation District's canal to the south. In 1923, the City and County of San Francisco (CCSF) and the Districts completed two storage projects in the basin C Hetch Hetchy (O'Shaughnessy) Dam and Don Pedro Dam. CCSF's Hetch Hetchy Dam (RM 117) has a reservoir storage capacity of 360,000 acre-feet. Water is diverted from Hetch Hetchy via an enclosed aqueduct to provide the municipal water supply for the City of San Francisco and other parts of the San Francisco Bay area. The Districts' Don Pedro Dam originally had a reservoir storage capacity of 290,000 acre-feet and was operated to provide agricultural water supply and hydroelectric generation. This dam was replaced in 1971 by the New Don Pedro Dam (RM 55.2), which increased storage capacity to 2,030,000 acre-feet and is operated for agricultural and municipal water supply, hydroelectric generation, recreation, and flood control. Access to the Tuolumne River by anadromous fish has been limited to the 52 miles downstream of La Grange Dam since 1871.

The Tuolumne River exhibits many of the features typical of regulated low gradient fluvial systems. Upstream dams and flow regulation have reduced the supply of coarse sediment available to the lower river and have reduced the frequency and duration of flows sufficient to mobilize the channel bed and inundate adjacent floodplains. As a result, the river channel downstream of the dams has fewer gravel bars and other depositional and erosional features that provide in-channel habitat complexity. Downstream of the dam, the Tuolumne is a meandering,

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low-gradient, alluvial river. From the dam downstream to RM 24 (2 river miles downstream of Geer Road), the channel is gravel-bedded and is characterized by low sinuosity and alternate bar morphology. From RM 24 to the Tuolumne River's confluence with the San Joaquin River, the channel is sand-bedded and is characterized by a more sinuous, alternate bar morphology.

The Tuolumne River and its floodplain downstream of La Grange Dam have been extensively altered by gold dredging and in-channel and floodplain aggregate mining. From the town of La Grange downstream to approximately RM 40 (near Roberts Ferry Road bridge), the river channel and floodplain were dredged for gold in the early Bto mid-twentieth century. These gold dredges excavated the river channel and floodplain to the depth of bedrock, often realigning the river channel, and deposited extensive areas of tailings (or spoils) onto the floodplain. The reaches of the river that were dredged are characterized by a long, straight, deep channel comprised almost entirely of run habitat and provide little structural complexity or habitat diversity. In addition, dredging displaced large areas of floodplain and riparian forest that historically bordered the river. In the early 1970s, much of these dredger tailings were removed from the floodplain and used in the construction of New Don Pedro Dam.

Past and current aggregate mining on the Tuolumne River extends from RM 51 to RM 25 and includes both in-channel and floodplain operations. Older mine operations generally excavated material directly from the river channel. These operations left behind large, in-channel pits that are up to several hundred feet wide and 5-35 feet (1.5-11 m) deep. In the Tuolumne River, these pits are referred to as Special Run Pools (SRPs) and occupy approximately 7.7 miles (12 km) of the 28-mile (45 km) gravel-bedded reach.

The SRPs impair geomorphic processes and provide habitat for warm-water, introduced fish species. Between RM 25.1 and RM 47.8, 11 reaches have been identified, including SRPs 2B10, in which hydraulic conditions under the current flow regime are insufficient to transport coarse bedload particles (McBain and Trush 1998). In these reaches, referred to as "bedload impedance reaches", all bedload being transported from upstream is trapped in the SRP rather than being transported downstream. In most of the bedload impedance reaches, no particles larger than coarse sand (4 mm) can be transported during high flow events (McBain and Trush 1998). As a result, bedload supply to reaches downstream of the pits is eliminated, and bedload is therefore recruited from the bed itself, causing bed degradation and coarsening. These SRPs also provide habitat for introduced bass species that prey on juvenile salmonids. Predation on juvenile fall chinook salmon in these pits has been a major focus of study on the Tuolumne River and has been found to be at times a primary factor limiting survival of juvenile fall chinook salmon in the lower Tuolumne River. These studies are described in detail in the Districts report to FERC (TID/MID 1992a and 1992b).

More recent mine operations have excavated material from the floodplain adjacent to the river channel. Extraction pits created by this floodplain mining are typically separated from the river by narrow embankments, many of which have been breached by floods. These breaches have resulted in several pits being temporarily or permanently connected to the river channel. Moreover, the pit embankments confine the river corridor often to widths of less than 300 feet (91 m). This confinement limits channel migration, eliminates floodplain and riparian habitats,

and results in increased flow depths and velocities during high flow events.

4.2 Essential Features of Steelhead Critical Habitat

NMFS identifies essential features of steelhead critical habitat as including adequate (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions. Surveys conducted to assess habitat quality and availability for fall chinook salmon and rainbow trout, provide some information regarding potential use of this reach by steelhead for spawning and rearing spawning habitat suitability and extent in the lower Tuolumne River downstream of La Grange Dam has been assessed for fall chinook salmon. These studies concluded that roughly three million square feet of habitat suitable for fall chinook spawning is available downstream of La Grange Dam depending on streamflow, bed armoring, vegetation encroachment, and site-specific flow characteristics (TID/MID 1992c). Available information regarding the status of each of these features in the Tuolumne River downstream of La Grange Dam is summarized below.

4.2.1 Substrate and Cover/Shelter

Both fall chinook and steelhead prefer similar flow velocities and minimum depths for spawning (Table 4). However, because Central Valley steelhead are typically smaller than Tuolumne River fall chinook salmon, they would be expected to utilize smaller spawning substrates. Due to the coarseness of the bed substrates in the Tuolumne River, the extent of suitable spawning habitat for steelhead would be expected to be less than that available for chinook salmon. In addition, large amounts of sand and fine sediment that have infiltrated into the river bed may severely limit steelhead survival-to-emergence. Thus, existing substrate in the Tuolumne River is not suitable habitat for sustaining a steelhead population in the Tuolumne River.

Adult steelhead require deep pools as cover for holding and resting during their adult spawning migration. Juvenile steelhead utilize coarse rocky substrates and boulder-log clusters as cover. During the warmer parts of the year, steelhead parr appear to prefer habitats with cover provided by rocky substrates, overhead cover, and low light intensities (Hartman 1965, Facchin and Slaney 1977, Ward and Slaney 1979, Fausch 1993). Age 1+ steelhead, which are typically found in pools, seek cover in the interstices of boulders and boulder-log clusters (Fontaine 1988, Bisson et al. 1988). During winter, steelhead prefer pool habitats with large rocky substrate or woody debris for cover (Hartman 1965, Swales et al. 1986, Raleigh et al. 1984, Fontaine 1988). When temperatures are low and flows are high, age 0+ steelhead tend to reside in rubble substrates (4-10 inch diameter [100-250 mm]) in shallow, low velocity areas near the stream margin (Bustard and Narver 1975), and age 1+ steelhead use interstices between assemblages of large boulders [>39 in (1 m) diameter], logs, and/or rootwads as winter cover (Bustard and Narver 1975, Everest et al. 1986).

The Tuolumne River downstream of La Grange Dam may not provide coarse substrate suitable for steelhead cover. In the bulk samples collected at riffles 4B and 36, the coarsest particles collected in five samples were <5 inches (<128 mm) (Stillwater Sciences, unpublished data). In

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bulk samples collected at eight riffles between RM 52 and RM 31.5 in 1987-1988, the coarsest particles collected in five samples were <4 inches (<100 mm). In addition, as discussed in Section 3.2.1, sand has infiltrated bed sediments and filled interstitial spaces throughout the gravel-bedded reach of the river. While the framework substrate bed consists primarily of coarse gravel and cobble, the bed sediments include a large sand component. In recent samples at Riffle 4B, the sand (<4 mm) component of all bulk samples was approximately 30 percent by weight. Freeze cores at this site demonstrate that sand completely filled interstitial spaces (Figure 10). The potential effects of lack of interstitial cover on steelhead rearing in Central Valley stream has not been determined.

A lack of interstitial cover has also been observed on the Mokelumne River, where despite efforts to improve conditions for steelhead, the population has continued to decline to the point that the run is not self-sustaining. In their assessment of East Bay Municipal Utility District's project impacts on steelhead in the Mokelumne River, FERC concluded that steelhead production was limited by the near absence of suitable rearing substrates downstream of Camanche Dam and that this rearing habitat limitation made recovery of steelhead A difficult, if not impossible downstream of Camanche Dam even given suitable flow conditions (FERC 1993, p. 5-2).

Table 4. Recommended spawning velocity and depth criteria for Oregon fall chinook salmon and winter steelhead.

| Species | Velocity (m/s) | Minimum Depth (m) |
|------------------|----------------|-------------------|
| fall chinook | 0.30-0.76 | 0.24 |
| winter steelhead | 0.40-0.91 | 0.24 |

(source: Smith 1973)

Sacramento River steelhead are generally smaller than those found in other California streams, except the Klamath River. Hallock et al. (1961) reported a bimodal length distribution with peaks at 15.5 inches (394 mm) for fish that spent one year at sea and 20.4 inches (518 mm) for those that spent two years at sea. These fish averaged about three pounds (1.4 kg); fish up to eight pounds (3.6 kg) pounds were common, while those over thirteen were rare (5.9 kg) (Hallock et al. 1961). Reynolds et al. (1993) state that Sacramento River steelhead generally weigh 2-12 pounds (0.9-5 kg.). In the Tuolumne River, most fall chinook salmon currently return at age 2-4-years. Fork length averages and ranges for these age classes are shown in Table 5.

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Table 5. Summary of fork length data for salmon aged by scale analysis for 1987-1989

| Year | | Fork Length (mm) | | | | | |
|------|------------------|------------------|-------------|-------------|-------------|-------------|-------------|
| | | Females | | | Males | | |
| | | 2-year olds | 3-year olds | 4-year olds | 2-year olds | 3-year olds | 4-year olds |
| 1987 | Mean | 601 | 730 | 810 | 626 | 680 | N/A |
| | Range | 520-710 | 730 | 810 | 470-750 | 680 | N/A |
| | Number sampled | 45 | 1 | 1 | 68 | 1 | 0 |
| | Percent of total | 96 | 2 | 2 | 99 | 1 | |
| 1988 | Mean | 653 | 747 | 770 | N/A | 888 | N/A |
| | range | 530-820 | 620-840 | 770 | N/A | 790-980 | N/A |
| | number sampled | 4 | 37 | 1 | 0 | 13 | 0 |
| | percent of total | 10 | 88 | 2 | | 100 | |
| 1989 | mean | N/A | 799 | 835 | N/A | 906 | 988 |
| | range | N/A | 680-900 | 720-930 | N/A | 780-980 | 830-1090 |
| | number sampled | 0 | 11 | 11 | 0 | 7 | 4 |
| | percent of total | | 50 | 50 | | 64 | 36 |

(source: TID/MID 1997)

Generally, gravel ranging in size from 0.25 to 5 inches (6.4 to 130 mm) in diameter is considered to be suitable for steelhead redd construction (Barnhart 1991). Several researchers have reported gravel composition that is successfully utilized by steelhead. The results of several studies are shown in Table 6. Inconsistent sampling methodologies used in various studies, however, makes comparison of results difficult because gravel composition can vary substantially depending on when, where, and how the sample is taken. Also, many studies do not indicate the size of the fish spawning in the study reaches. Because fish size varies internally and geographically and because substrate suitability is dependent on fish size, results from these studies are not necessarily directly applicable in regions other than the immediate study area.

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Table 6. Substrate sizes suitable for steelhead spawning.

| Substrate Size Range (mm) | Median Diameter (d₅₀) (mm) | Region | Comments | Source |
|--|--|---------------|---|-------------------------|
| 51-27 | -- | N. California | Using the average diameter of the large rocks which formed the most conspicuous part of the redd structure (only 1 fish measured-749 mm, 3.4 kg) | Briggs 1953 |
| -- | 10.4-23 | Washington | samples collected using McNeil samplers and sieved (fish size not reported) | Cederholm and Salo 1979 |
| 12.7-102 | -- | Idaho | samples taken from redds; samples collected using McNeil samplers and sieved (fish size not reported) | Orcutt et al. 1968 |
| -- | 10.4-46 | various | Literature review | Kondolf and Wolman 1993 |
| 6-76 | | Oregon | steelhead from three to 15 pounds (average approximately six pounds) | Huntington 1985 |

Tuolumne River substrate composition was assessed in 1987, 1988, and 1998. In 1987 and 1988, the Districts assessed spawning gravel quality in the reach from La Grange Dam downstream to Waterford (RM 32) (TID/MID 1992d). For this evaluation, 72 randomly located bulk samples were collected at eight riffles in the spawning reach prior to the onset of spawning. After the 1987-88 spawning season, 29 bulk samples were collected in redds in three riffles. These samples have not been assessed with regard to steelhead suitability. This analysis would provide additional information regarding spawning conditions for steelhead in the lower Tuolumne River.

In 1998, potential spawning gravels were sampled from riffles 4B (RM 48.8) and 36 (RM 37.5) (Stillwater Sciences, unpublished data). The median grain size of these samples ranged from 1.0 to 1.6 inches (25 to 40 mm), and the d₅₀ ranged from 3.2 to 4.3 inches (83 to 110 mm) (Table 7). These median grain sizes are coarser than those reported by Cederholm and Salo (1979) but are within the upper end of the range reported by Kondolf and Wolman (1993). Using the d₅₀ to represent to the upper end of the range of gravel sizes, the size range is within the range reported by Briggs (1953) and Orcutt et al. (1968) but exceeds the range reported by Huntington (1985).

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Of these studies shown in Table 7, the two that reported fish size (Briggs 1953 and Huntington 1985) evaluated spawning conditions for steelhead that were much larger than Central Valley steelhead. Because the Central Valley steelhead are smaller, they would be expected to utilize smaller spawning substrates than that reported by Briggs (1953) and Huntington (1985). The extent of spawning habitat available for steelhead would be expected to be less than that available for chinook salmon. The actual extent has not been determined.

Table 7. Grain size characteristics of spawning gravels in the lower Tuolumne River (from samples collected in 1998).

| Location | | d ₅₀ (mm) | d ₉₅ (mm) |
|----------|---------------|----------------------|----------------------|
| Riffle | Sample Number | | |
| R4B | 4 | 25 | 83 |
| R4B | 6 | 25 | 110 |
| R4B | 7 | 40 | 100 |
| R36 | 1 | 40 | 100 |
| R36 | 2 | 35 | 110 |

In addition, successful incubation and emergence require spawning substrates to be relatively free of sand and fine sediment. Downstream of dams, lack of bed mobilization often permits fine sediment and sand to accumulate in spawning gravels. Excessive amounts of fine sediment and sand can reduce interstitial flow of water in spawning substrates, thereby decreasing dissolved oxygen delivery to developing eggs and alevins. Fine sediment and sand may also prevent emergence by impeding passage up through the gravels.

In 1987 and 1988, the Districts assessed the effects of fine sediment and sand on survival-to-emergence of fall chinook salmon in the Tuolumne River. This assessment used two approaches: (1) predicting survival-to-emergence based on substrate composition using the model developed by Tappel and Bjornn (1983), and (2) documenting actual survival-to-emergence by trapping fry emerging from natural redds (TID/MID 1992d). Mean survival predicted by the Tappel-Bjornn survival-to-emergence model (which is based on substrate composition) for the riffles sampled in 1987 was 15.7 percent. Predicted mean survival from redds sampled in 1988 was 34.1 percent. Survival-to-emergence as documented by emergence trapping was one percent in 1988 and 32 percent in 1989. (Low emergence in 1988 was likely due to high water temperatures that occurred during incubation.) Comparison of predicted and observed egg-to-emergence survival in the Tuolumne River with that in the literature suggests that survival-to-emergence of fall chinook salmon in the Tuolumne River is substantially reduced due to poor gravel quality.

Similarly low survival-to-emergence would also be anticipated for steelhead (Tappel and Bjornn 1983).

4.2.2 Water Quality

Water quality evaluations on the Tuolumne River have focused on water temperature (see Section 4.2.4 below). A summary of other water quality issues that may affect salmonids can be found in Brown (1996). As part of the National Water-Quality Assessment Program, the U.S. Geological Survey (USGS) began a full-scale water quality assessment in the San Joaquin Basin in 1991. Water quality factors of concern in the San Joaquin Tulare Basin study unit included concentrations of pesticides, nutrients, and naturally occurring trace elements in surface and ground water, and concentrations of pesticides and trace elements in biota. Past gold mining, agriculture, and urbanization are important sources of contaminants in the Tuolumne River and San Joaquin basin. Leland and Scudder (1990, as cited in Brown 1996) reported relatively high concentrations of certain trace elements (e.g., mercury, cadmium, copper) in tissues of the clam *Corbicula* sp. and in fine sediments in the Tuolumne River compared to levels found in the San Joaquin River. Mercury found in fine sediment and tissues of organisms likely result primarily from the use of mercury in past gold mining operations. Pesticides have been detected in the water column and in the sediments of the San Joaquin River and its tributaries, but their importance with regard to water quality varies seasonally (Brown 1996). At least 350 different pesticides have been recently in use in the San Joaquin Tulare Basin (Brown 1996). Significant loads of pesticides are primarily released (1) in December and January when dormant orchards are sprayed for insect control and when subsequent rainfall flushes the pesticides into surface water, and (2) in March and April when alfalfa fields are treated to control insects (Brown 1996). Diazinon is one of the most commonly used compounds and appears to take much longer to degrade in the aquatic environment than other pesticides (Kuivila 1993, as cited in Brown 1996). Pesticide residues in fish have been studied at 32 sites in the area as part of a toxic substances monitoring program (TSMP) run by the California State Water Resources Control Board (Reassumes and Blethrow 1990, 1991, Rasmussen 1992, all as cited in Brown 1996). Although the use of DDT was banned in 1972, it continues to persist in the sediment of the San Joaquin River and its tributaries (Pereira et al. 1996). The pesticide dicofol, which is commonly used in the basin, has been reported to contain significant amounts of DDT, DDD, and DDE isomers as manufacturing impurities and may be the source of DDT and its degradates in the system (Pereira et al. 1996). DDT, DDE, dieldrin, and dicofol have recently been possibly implicated as endocrine disruptors or "environmental hormones" that mimic natural hormones such as estrogen and that may cause emasculation, abnormal sexual development, and impaired reproduction in animals (Hileman 1994, Colborn and Clement 1992, Colborn et al. 1993, all as cited in Pereira et al. 1996). A recent study by Canada's federal Department of Fisheries and Oceans and Environment suggests that the use of endocrine-disrupting chemicals in Canadian forests may reduce survival of Atlantic salmon during their migration from fresh to salt water (Morris 1999). Concentrations of total DDT have been high in TSMP samples from the lower San Joaquin River in almost every year (Brown 1996). Samples that exceeded the FDA human-health action level criteria of 5,000 ng/g wet weight were collected from the Tuolumne River (Rasmussen and Blethrow 1990, 1991, as cited in Brown 1996). Chlordane and hexachlorobenzene also was found to exceed criteria in the Tuolumne River (Brown 1996).

4.2.3 Water Quantity

Minimum Flows

Minimum instream flows in the Tuolumne River are regulated by Article 37 of the FERC license for the New Don Pedro Project. Under the original Article 37 (1964), the required minimum instream flow varied between 40,123 acre-feet and 123,210 acre-feet per water year (October 1 through September 30) depending on the water year type (Table 8).

Schedule A or Schedule B of the 1964 flow schedule applied in a given year based on total inflow to New Don Pedro Reservoir during the previous water year (1 October-30 September). When inflow exceeded 1 million acre-feet, Schedule A applied. When inflow was between 750,000 and 1 million acre-feet, Schedule B applied. When inflow was less than 750,000 acre-feet, the amount of water provided under Schedule B would be reduced by a percentage of the total acre-feet equivalent to the percent reduction in the gravity diversion at La Grange by the Districts. Further modifications of Schedule A flows were made from 1987-1992 to meet the terms of a 1986 study plan agreement between the Districts, CDFG and USFWS.

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Table 8. Minimum flow requirements established in Article 37 of the 1964 FERC license.

| Period | Schedule A Normal Year (cfs) | Schedule B Dry Year (cfs) |
|-------------------------|---|--|
| Preseason flushing flow | 2,500 | -- |
| October 1-15 | 200 | 50 |
| October 16-31 | 250 | 200 |
| November | 385 | 200 |
| December 1-15 | 385 | 200 |
| December 16-31 | 280 | 135 |
| January | 280 | 135 |
| February | 280 | 135 |
| March | 350 | 200 |
| April | 100 | 85 |
| May-September | 3 | 3 |
| Total (acre-feet) | 123,210 | 64,040 |

A revised minimum flow schedule was negotiated during the 1995 FSA process. This revised schedule, which is contained in the 1995 FSA and the 1996 license amendment, provides for a minimum flow requirement in all water years of 94,000 acre feet and increasing up to 300,923 acre feet in the wetter 50 percent of the water years (Table 9, Figure 2). The goal of this flow schedule was to improve habitat for all freshwater life stages of fall chinook salmon and to provide some chinook salmon oversummering habitat near La Grange Dam for the expression of the stream-type life history strategy. Flows necessary to meet the requirements of fall chinook salmon were determined based on the USFWS Instream Flow Incremental Methodology (IFIM) analysis and the Districts' temperature-dependent IFIM analysis. The latter approach used the Tuolumne River SNTMP model (Theurer et al. 1984) to generate temperatures and eliminated Weighted Usable Area (WUA) for which life-stage-specific temperature requirements¹ were exceeded (TID/MID 1993). Under the new schedule, flows have been increased from April through September for all water year types, a fall attraction pulse has been increased in 50

Evaluation temperatures were 56°F (13.3°C) for spawning and 68°F (20°C) for fry and juvenile rearing.

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percent of years, and a spring outmigration pulse flow has been provided in all years. The 1995 FSA modifications to the flow schedule are expected to provide the following benefits to fall chinook salmon: reduced water temperatures for rearing and outmigration, improved attraction of adult salmon, increased spawning habitat area, improved stimulation of juvenile outmigration prior to temperature increases in the summer, increased survival of outmigrants, and improved conditions for oversummering. The suitability of these flows for steelhead spawning and rearing have not been evaluated.

Table 9. 1995 FSA Minimum Flow Schedule.

| Water Year Type | Percent Occurrence | Oct 1B15 (cfs) | Attraction Flow (acre-feet) | Oct 16B May 31 (cfs) | Outmigration Pulse Flow (acre-feet) | June 1B Sept 30 (cfs) | Total Flow (acre-feet) |
|--|--------------------|----------------|-----------------------------|----------------------|-------------------------------------|-----------------------|------------------------|
| Critical and below normal | 6.4 | 100 | None | 150 | 11,091 | 50 | 94,000 |
| Median critical | 8.0 | 100 | None | 150 | 20,091 | 50 | 103,000 |
| Intermediate critical/dry | 6.1 | 150 | None | 150 | 32,619 | 50 | 117,016 |
| median dry | 10.8 | 150 | None | 150 | 37,060 | 75 | 127,507 |
| Intermediate dry/below normal | 9.1 | 180 | 1,676 | 180 | 35,920 | 75 | 142,502 |
| Median below normal | 10.3 | 200 | 1,736 | 175 | 60,027 | 75 | 165,002 |
| Intermediate below normal/above normal | 15.5 | 300 | 5,950 | 300 | 89,882 | 250 | 300,923 |
| Median above normal | 5.1 | 300 | 5,950 | 300 | 89,882 | 250 | 300,923 |
| Intermediate above normal/wet | 15.4 | 300 | 5,950 | 300 | 89,882 | 250 | 300,923 |
| median wet/maximum | 13.3 | 300 | 5,950 | 300 | 9,882 | 250 | 300,923 |

4.2.4 Water Temperature

As discussed in Section 2.1, the Districts conducted extensive water temperature monitoring in the lower Tuolumne River which indicated that prior to implementing the 1995 FSA minimum flow schedule, water temperatures in the Tuolumne River downstream of La Grange Dam typically exceeded 60 -70°F (15.6°C) all or a portion of the summer. Water temperatures

anticipated to occur under the 1995 FSA minimum flow schedule have been predicted using the Districts' Tuolumne River temperature model. This model, which is a river-specific model developed using SNTMP (Theurer et al. 1984), predicts 5-day mean water temperatures at 3.1-mile intervals from New Don Pedro Dam to RM 2.3 based on meteorological conditions, flow, shading, channel geometry, and channel network. The predicted water temperatures for several locations for each 1995 FSA water year type are shown in Figures 3 through 9. These predictions are based on mean 1978-1988 meteorological conditions and therefore do not depict unusually warm or unusually cool scenarios. The results indicate that water temperature $\leq 60^{\circ}\text{F}$ would occur throughout the summer and early fall immediately downstream of La Grange Dam in all water year types and downstream to between RM 48.9 and RM 45.8 during "intermediate below normal-above normal" and wetter years (49.3 percent occurrence) (Table 11), suggesting that in nearly half of all years temperatures within NMFS's 60°F criterion would be provided to 3.3-6.4 miles downstream of La Grange Dam.

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Table 11. Months when NMFS evaluation temperature (60°F) for steelhead rearing is exceeded for flows required in the 1995 FSA at locations downstream of La Grange Dam.

| Water Year Type (predicted occurrence) | River Mile | Month | | | | | | | | | | | |
|---|---------------|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| Critical & Below (6.4%) | 52.0 | | | | | | | | | | | | |
| | 48.9 | | | | | | | | X | X | X | X | X |
| | 45.8 | X | | | | | | | X | X | X | X | X |
| | 42.7 | X | | | | | | | X | X | X | X | X |
| Median Critical (8.0%) | 52.0 | | | | | | | | | | | | |
| | 48.9 | | | | | | | | X | X | X | X | X |
| | 45.8 | X | | | | | | | X | X | X | X | X |
| | 42.7 | X | | | | | | | X | X | X | X | X |
| Intermediate Critical-Dry (6.1%) | 52.0 | | | | | | | | | | | | |
| | 48.9 | | | | | | | | X | X | X | X | X |
| | 45.8 | | | | | | | | X | X | X | X | X |
| | 42.7 | X | | | | | | | X | X | X | X | X |
| Median Dry (10.8%) | 52.0 | | | | | | | | | | | | |
| | 48.9 | | | | | | | | X | X | X | X | X |
| | 45.8 | | | | | | | | X | X | X | X | X |
| | 42.7 | X | | | | | | | X | X | X | X | X |
| Intermediate Dry-Below Normal (9.1%) | 52.0 | | | | | | | | | | | | |
| | 48.9 | | | | | | | | | X | X | X | X |
| | 45.8 | | | | | | | | X | X | X | X | X |
| | 42.7 | X | | | | | | | X | X | X | X | X |
| Median Below Normal (10.3%) | 52.0 | | | | | | | | | | | | |
| | 48.9 | | | | | | | | | X | X | X | X |
| | 45.8 | | | | | | | | X | X | X | X | X |
| | 42.7 | X | | | | | | | X | X | X | X | X |
| Intermediate Below Normal- Above Normal Median Above Normal Intermediate Above Normal- Wet Median Wet/Maximum (49.3%) | 52.0 | | | | | | | | | | | | |
| | 48.9 | | | | | | | | | | | | |
| | 45.8 | | | | | | | | | X | X | X | X |
| | 42.7 | | | | | | | | X | X | X | X | X |

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The NMFS temperature criteria, however, may be much than lower actual suitable temperature ranges for Central Valley steelhead. Myrick (1998) provides the only available experimental assessment of temperature tolerances specifically for Central Valley steelhead. These experiments, which used steelhead that were reared at the Mokelumne River Hatchery from eggs were collected at the Nimbus Fish Hatchery (American River), indicated that Central Valley steelhead prefer higher temperature ranges than those reported in the literature for other stocks, with preferred rearing temperatures for Central Valley steelhead ranging from 63 to 68°F (17 to 20°C) and a maximum temperature tolerated (lethal critical thermal maximum) of 80°F (27°C).

It is unlikely, that steelhead spawned and reared in significant numbers in the Tuolumne River downstream of La Grange Dam (i.e., the reach currently accessible to anadromous salmonids). Under historical conditions, late summer and early fall flows in the lower river were low in most years. Late summer and early fall unimpaired flows² in the lower Tuolumne River are shown in Table 1. Water temperatures during these low flow periods (particularly in October) were likely unsuitable for steelhead rearing and likely restricted rearing distribution to cooler reaches in the mainstem and tributaries in the middle and upper watershed. For comparison, minimum late summer flows required by the 1995 Federal Energy Regulatory Commission (FERC) Settlement Agreement (California Department of Fish and Game et al. 1995) are shown in Table 2. Note that October flows required by the 1995 FSA minimum flow schedule are nearly twice the median year unimpaired flows for Intermediate Below Normal-Above Normal and wetter years (49.3 percent occurrence) and approximately equal to or greater than median year unimpaired flows for Intermediate Dry-Below Normal and Median Below Normal years (19.4 percent occurrence).

Table 1. Later summer and early fall unimpaired flow conditions in the Tuolumne River (1921-1994).

| Water Year Type ³ (representative water year) | Average Monthly Discharge (cfs) | | |
|--|---------------------------------|-----------|---------|
| | August | September | October |
| Dry (1988) | 98 | 16 | 179 |
| Median (1971) | 325 | 163 | 179 |
| Wet (1952) | 878 | 276 | 146 |

Table 2. 1995 FSA later summer and early fall flow requirements.

² Unimpaired flows are flows that would occur in the absence of dams in the watershed and have been computed by the California Department of Water Resources for water years 1921-1994.

³ Dry, median, and wet water year types are defined as years ranking at the 10th, 50th, and 90th percentile of total annual discharge, respectively.

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| Water Year Type (representative water year) | Percent Occurrence | Required Minimum Flow (cfs) | | |
|---|-----------------------|-----------------------------|-----------|---------|
| | | August | September | October |
| Critical & Below | 6.4 | 50 | 50 | 100-150 |
| Median Critical | 8.0 | 50 | 50 | 100-150 |
| Intermediate C-D | 6.1 | 50 | 50 | 150 |
| Median Dry | 10.8 | 75 | 75 | 150 |
| Intermediate Dry- Below Normal | 9.1 | 75 | 75 | 180 |
| Median Below Normal | 10.3 | 75 | 75 | 175-200 |
| Intermediate Below Normal-Above Normal Median Above Normal Intermediate Above Normal-Wet Median Wet/Maximum | 49.3 | 250 | 250 | 300 |

Since 1923 when the original Don Pedro Dam became operational, managed flows likely severely limited potential *O. mykiss* distribution and abundance in the Tuolumne River. From 1923 through 1970, summer flows of less than 25 cubic feet per second (cfs) occurred in 33 of the 34 years of record. (The original Don Pedro Dam regulated flows during this period.) Under the New Don Pedro Project's original Federal Energy Regulatory Commission (FERC) license, a daily average flow of less than 25 cfs occurred during summer in 20 of the 24 years of record. A new FERC order in 1996 increased the summer minimum flow requirements, which now range from 50-250 cfs depending on year type (FERC 1996).

Since 1987, the Districts have monitored water temperature downstream of La Grange Dam using thermographs deployed throughout the lower river and in recent years in the mainstem San Joaquin River. Locations and periods of record of these thermographs are shown in Table 3. Temperature data recorded at the most upstream thermographs (i.e., thermographs located in the coolest reach of the river downstream of La Grange Dam) are provided in Appendix B. Since 1971, water temperature data are also available at the USGS gauge Tuolumne River below La Grange Dam, near La Grange (number 11289650) located at RM 50.5. At the USGS gauge, maximum daily temperature exceeded the NMFS temperature evaluation criterion of 60°F (15.6°C) for juvenile rearing in 19 years of the 28-year period of record. Similarly, mean daily water temperatures recorded by the District's thermographs exceeded 60°F at least as far upstream as Riffle 4B (RM 48.5) or Riffle 3B (RM 49) in seven years of the 11-year period of record⁴, at least as far upstream as RM 43.3 in two years of the 3-year period of record, at least

⁴ Locations of thermograph deployment varied from year to year. Periods of record at each location, therefore, are inconsistent.

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far upstream as RM 42.0 for all seven years of record, and at least as far upstream as RM 36.7 in ten of the 11 years of record. Mean daily water temperatures recorded by the thermographs exceeded 70°F at least as far upstream as Riffle 4B (RM 48.5) or Riffle 3B (RM 49) in six years of the 11-year period of record. The only years in which water temperature did not exceed 70°F at least as far upstream as Riffle 4B (RM 48.5) or Riffle 3B (RM 49) were 1993 and 1995-1998, all of which were above normal water years. These summer water temperatures would likely have precluded trout reproduction or rearing in the Tuolumne River downstream of La Grange Dam in most years.

Table 3. Thermograph locations for the San Joaquin and Tuolumne Rivers.

| RM (Approximate) | Thermograph Location | Period of Record |
|--------------------------|---------------------------------------|---------------------|
| <i>Tuolumne River</i> | | |
| 49 | Riffle 3B | 1990-1998 |
| 48.5 | Riffle 4B | 1987-1989 |
| 43.5 | Riffle 19 | 1996-1998 |
| 41.5 | Turlock Lake State Recreation Area | 1987-1994 |
| 36.5 | Ruddy Gravel | 1987-1998 |
| 31.5 | Hickman | 1987-1991 |
| 24.5 | Charles Road | 1988-1996 |
| 23.5 | Hughson | 1997-1998 |
| 21.5 | Empire | 1987-1988 |
| 16.5 | Dry Creek | 1987-1990 |
| 12.3 | Riverdale Park | 1988-1996 |
| 3.6 | Shiloh | 1987-1998 |
| <i>San Joaquin River</i> | | |
| 80 | Gardner Cove | 1987-1998 |
| 86.2 | Dos Rios | 1996-1998 |

4.2.5 Water Velocity

Water velocity is spatially highly variable. Changes in the timing, magnitude, or duration of high flows resulting in increased water velocity may affect steelhead by (1) limiting the amount

of habitat suitable for spawning and rearing, (2) mobilizing spawning gravels during incubation and causing displacement of eggs and alevins, (3) displacing fry or juvenile steelhead downstream to areas less suitable for rearing, (4) altering cues used for smolt outmigration, and (5) creating velocity barriers to upstream migration of adults. Evaluation of potential effects of flow regulation on water velocities that would affect freshwater life stages of steelhead is available from the 1981 and 1992 IFIM studies.

4.2.6 Cover/Shelter

The Tuolumne River has limited amounts of large woody debris (LWD). A detailed evaluation of the availability of instream and overhead cover has not been conducted in the lower Tuolumne River. Detailed habitat mapping has been completed at Phase I of the Gravel Mining Reach site (RM 34.5 to RM 40.3) and at SRPs 9 and 10 (RM 25.1 to RM 26.0). In these reaches instream cover was found to be lacking.

4.2.7 Food

While no steelhead-specific food supply studies have been done, assessment of food supplies for chinook salmon suggest that supplies are ample. However, the accuracy of those studies are questionable, for reasons stated below. The adequacy of the food supply for juvenile fall chinook salmon was assessed by the Districts based on gut samples, drift samples, and benthic samples (TID/MID 1992f) and 96-9. Prey species preferred by fall chinook salmon were identified by gut samples, which found that juvenile salmon preferentially consumed chironomids (midges), ephemeropterans (mayflies), and dipterans (true flies). Invertebrate densities were assessed using drift and benthic samples, the latter of which used a 0.1 m² Hess sampler. Analysis of these data using food limitation indices developed by Keup (1988) suggested that food limitation was unlikely. The assessment provided by this index may be inaccurate, however, because (1) the index was developed for small trout streams, (2) the data provide no information about food availability in seasons during which no samples were collected (e.g., winter), and (3) the relationship between benthic invertebrate density and carrying capacity has not been sufficiently defined. The Tuolumne River was found to be relatively rich in taxa and had a high invertebrate density. The adequacy of food supply for steelhead has not been evaluated, but was considered adequate for salmon in the low flow years that were sampled.

4.2.8 Riparian Habitat and Functions

NMFS defines steelhead critical habitat based on key riparian functions, specifically shade, sediment, nutrient or chemical regulation, streambank stability, and input of large woody debris or organic matter (NMFS 1999, p. 5744). In 1998, the TRTAC completed an inventory of riparian vegetation in the lower Tuolumne River corridor (McBain and Trush 1998). The functions of this riparian zone, however, have not been evaluated.

Native riparian forests along the Tuolumne River have been reduced to about 15 percent of their historical extent (McBain and Trush 1998). Riparian vegetation in the sand-bedded reaches was described as a lush, multi-layered "gallery forest" with vines connecting the canopy tree layer

with a dense underbrush of shrubs, grasses and forbs. In gravel-bedded reaches, the riparian vegetation was restricted between bluffs, persisting only in areas with adequate soil moisture and protection from harsh flooding conditions (McBain and Trush 1998).

Large-scale removal of riparian vegetation was the direct result of mining activities and urban/agricultural encroachment. Clearing of riparian forests has decreased large woody debris recruitment, allowed exotic plants to invade the riparian corridor, reduced shading of the water's surface, and contributed to increased water and air temperatures in the Tuolumne River corridor (McBain and Trush 1998). Grazing and other land uses have resulted in direct impacts on riparian vegetation.

Flow and sediment regulation have indirectly impacted Tuolumne River riparian vegetation by modifying the hydrologic and fluvial processes that influence the vegetation's establishment, survival, and succession (McBain and Trush 1998). The virtual elimination of large floods by upstream dams as required by the Army Corps of Engineers (ACOE) has allowed riparian stands in some areas to mature into even-aged stands. Some of these stands have permanently encroached on the channel and have anchored in place historically dynamic alluvial features (McBain and Trush 1998).

Exotic plants have become well established because they are better adapted to the altered riparian corridor environment. Exotic plants comprise 10 of 33 vegetation types documented in the Tuolumne River riparian corridor and often grow in pure stands that exclude all other plant species. Four species--eucalyptus (*Eucalyptus* spp.), edible fig (*Ficus carica*), giant reed (*Arundo donax*), and tree of heaven (*Ailanthus altissima*)--comprise the most common exotic plants found in the corridor.

5. Efforts to Improve Salmonid Habitat Conditions in the Tuolumne River

As discussed in Section 4.2.3, the 1995 FSA increased minimum flow requirements in an effort to improve fall chinook salmon habitat. The 1995 FSA also directs the TRTAC to identify ten priority restoration projects to improve fall chinook salmon habitat, including a minimum of two salmon predator pond isolation projects, with the objective of implementing the priority projects by the year 2005. As a foundation for this effort, the TRTAC developed a comprehensive restoration plan for the lower Tuolumne River corridor. Many of the actions identified by this plan to benefit fall chinook salmon would likely benefit steelhead. The TRTAC is the lead in the development of the Corridor Restoration Plan, restoration project identification, project monitoring, and is assisting in obtaining Federal and State funding. Turlock Irrigation District is the restoration program manager and is responsible for the design, environmental review, funding coordination, and construction of the restoration projects and has established a restoration program management team to carry out those responsibilities. This function is coordinated with CDFG's habitat restoration program, which includes Tuolumne River projects.

The Tuolumne River Corridor Restoration Plan is intended to serve as a source of information for use by other agencies and groups managing the resources of the Tuolumne River corridor. The Plan seeks to improve ecological conditions capable of supporting a sustainable and resilient

fall chinook salmon population in the Tuolumne River and is based on an integrative approach to re-establishing critical ecological functions, processes, and characteristics within contemporary regulated flow and sediment conditions that best promote recovery of the river's salmon population and other native plant and animal communities. This approach combines immediate, active restoration measures to "jump-start" the river's recovery, followed by flow and sediment management to re-establish geomorphic and ecological processes (such as floodplain inundation, riparian vegetation succession, and coarse sediment transport). Because historical and contemporary impacts to the Tuolumne River far exceed the river's ability to recover through natural regenerative processes within an acceptable time frame, active restoration measures (primarily channel/floodplain reconstruction and coarse sediment augmentation) are necessary to provide suitable habitat and geomorphic conditions in the near-term. The success of the program in achieving these benefits will be monitored by the TRTAC and CDFG.

Projects currently being implemented and projects for which implementation funding is currently being sought are described in Appendix E.

6. Effects of Habitat Management

6.1 Activities that Affect the Area or Could be Affected by the Designation

The main District activities that affect the proposed critical habitat area and that could be affected by designation of critical habitat are (1) flow regulation and (2) implementation of in-channel and floodplain restoration projects. As described in Section 3.1 above, the District's and CCSF's dams regulate flow in the Tuolumne River for diversion to agricultural and domestic uses. As a result, flow in the lower Tuolumne River is on average reduced compared to natural conditions. Reduced flows and elevated water temperatures during the summer months limit steelhead establishment in the lower Tuolumne River. Under natural conditions, however, flows in the lower river were typically low in the late summer and early fall and likely limited steelhead occurrence in the lower watershed. The 1995 FSA minimum flow schedule provides late summer and early fall flows close to or greater than flows under unimpaired conditions in some cases (See Section 4.2.3).

In addition, the District's river restoration efforts may affect steelhead. Once completed, these efforts would likely improve habitat suitability for steelhead. During construction, however, habitat disturbance and displacement may adversely impact this species. Any adverse impacts would likely be mitigable by implementing of standard Best Management Practices. Because the projects receive federal funding and authorization, consultation with NMFS pursuant to Section 7 of the ESA would be required to ensure that adverse impacts to steelhead (if they are determined to occur in the Tuolumne River) and steelhead critical habitat (if it is designated in the Tuolumne River) could be required.

6.2 Economic Costs and Benefits of Additional Requirements of Management Measures Likely to Result from the Designation

NMFS considers economic and other impacts resulting from designation of critical habitat to be

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only those that are incremental to and above the economic and other impacts attributable to listing the species or resulting from other authorities. Since listing a species under the ESA provides significant protections to the species' habitat, in many cases NMFS considers the economic and other impacts of a critical habitat designation, over and above the impacts of the listing itself, to be minimal.

In general, designation of critical habitat highlights geographical areas of concern and reinforces protections resulting from the listing itself. Also, the only regulatory impact of a critical habitat designation is through Section 7 of the ESA. Under Section 7 provisions, the designation of critical habitat requires federal agencies undertaking actions, issuing permits, or providing funding for actions to ensure that they are not likely to result in the destruction or adverse modification of the designated critical habitat.

If a self-sustaining population of steelhead is present in the Tuolumne River:

Assuming that steelhead are present in the Tuolumne River, the designation of critical habitat likely would not result in the requirement of measures above those required to protect the species in the absence of the critical habitat designation. These measures would likely be identified and required through a Section 7 consultation process or through a Section 10 Habitat Conservation Plan process. The Section 7 process is initiated only when a federal action is involved. Regarding dam operations and flow conditions, NMFS considers the continuing implementation of an existing FERC license to be a federal action. NMFS is currently coordinating with FERC to identify and prioritize hydropower licenses that may warrant re-initiation Section 7 consultation in light of recent salmonid listings (Keith Kirkendall, NMFS, personal communication). A Section 10 process likely would not be initiated until NMFS issues their Section 4(d) rules for steelhead. Because Section 4(d) rules are required to define take of a threatened species, NMFS cannot enforce take actions until these rules are finalized. The Section 10 process is voluntary and provides private parties an avenue for consulting with NMFS to avoid Section 9 take enforcement actions.

If steelhead are not present in the Tuolumne River:

Assuming that steelhead are not present in the Tuolumne River, critical habitat designation could result in the requirement of significant measures to ensure that actions undertaken, funded, or authorized by the federal government do not result in the destruction or adverse modification of critical habitat. Because access to cooler rearing areas in the middle watershed has been eliminated, NMFS may consider requiring increased flows to provide suitable rearing temperatures downstream of La Grange Dam. The most significant action that might be anticipated is the requirement of summer flows sufficient to provide suitable rearing temperatures for steelhead downstream of La Grange Dam. NMFS has indicated that it will require consultation when water temperature exceeds 65 °F (18° C) (Dennis Smith, NMFS, personal communication). The Bureau of Reclamation is currently negotiating with NMFS to establish summer rearing flows on the Stanislaus River. Using the SNTMP model, we have estimated flows that would be necessary to maintain water temperatures $\leq 60^{\circ}\text{F}$ to various locations downstream of La Grange Dam. These estimates are based on average 1978-1988

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meteorological conditions and therefore do not represent unusually hot or cold periods that may occur. The results of this evaluation for mean 1978-1988 meteorological conditions are shown in Figure 10. Results for meteorological and water year conditions specific to individual years are shown in Appendix F. We have also computed additional water volume needed to provide $\leq 60^{\circ}\text{F}$ temperatures to various locations based on individual water year types experienced from 1978 through 1988. The additional volume of water required ranges from 14,000 to 147,000 acre-feet annually depending on the location to which suitable temperatures are provided and the water year type (Table 12). In addition, designation of critical habitat may result in additional monitoring requirements in the lower Tuolumne River, particularly real-time temperature monitoring and flow management. A complete analysis of the water volume required is impossible due to the failure of NMFS to define "specific" areas as required by Section 3(5)(A) of the Act.

Table 12. Flows required to maintain water temperature $\leq 60^{\circ}\text{F}$ in the Tuolumne River for 1978-88 meteorological conditions and water year types¹.

| Water Year | 1995 FSA flows | ADDITIONAL FLOW NEEDED TO MAINTAIN 60 F to ... | | | | | | | | | |
|-----------------|----------------|--|---------|---------|---------|---------|--------|---------|---------|---------|---------|
| | | RM 52.0 | RM 42.7 | RM 33.4 | RM 24.0 | RM 14.7 | RM 2.3 | RM 52.0 | RM 42.7 | RM 33.4 | RM 24.0 |
| | (TAF) | TAF | | | | | | Percent | | | |
| 1978 | 301 | 0 | 29 | 122 | 274 | 410 | 563 | 0 | 10 | 40 | 91 |
| 1979 | 301 | 0 | 20 | 111 | 270 | 436 | 596 | 0 | 7 | 37 | 90 |
| 1980 | 301 | 0 | 34 | 136 | 317 | 507 | 672 | 0 | 11 | 45 | 105 |
| 1981 | 143 | 0 | 101 | 234 | 462 | 682 | 893 | 0 | 71 | 165 | 324 |
| 1982 | 301 | 0 | 35 | 137 | 304 | 467 | 614 | 0 | 12 | 46 | 101 |
| 1983 | 301 | 0 | 74 | 218 | 414 | 627 | 773 | 0 | 25 | 72 | 138 |
| 1984 | 301 | 0 | 52 | 178 | 395 | 627 | 798 | 0 | 17 | 59 | 131 |
| 1985 | 143 | 0 | 67 | 169 | 346 | 514 | 650 | 0 | 47 | 118 | 243 |
| 1986 | 301 | 0 | 33 | 134 | 304 | 476 | 622 | 0 | 11 | 44 | 101 |
| 1987 | 103 | 0 | 84 | 196 | 382 | 558 | 716 | 0 | 82 | 190 | 371 |
| 1988 | 94 | 1 | 91 | 200 | 374 | 507 | 664 | 1 | 96 | 213 | 398 |
| total (1978-88) | 2,588 | 1 | 619 | 1,834 | 3,842 | 5,812 | 7,561 | 0 | 24 | 71 | 148 |

¹Temperatures and required flows are based on SNTMP model predictions.

7. Impacts of Natural and Artificial Barriers

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NMFS believes that currently accessible habitat may be sufficient for the conservation of affected steelhead ESUs but states that the potential for restoring access to former spawning and rearing areas upstream of currently impassable anthropogenic barriers will be a significant factor in determining whether these upstream areas are essential to the conservation of the ESU. NMFS will determine on a case-by-case basis during FERC relicensing whether fish passage facilities will be required (NMFS 1999, p. 5746).

La Grange Dam is the upstream limit of the Tuolumne River currently accessible to anadromous fish. Yoshiyama et al. (1996) estimated that construction of La Grange Dam eliminated access by spring chinook salmon to at least 50 miles of formerly accessible stream upstream of the dam. Because steelhead typically ascended further upstream than spring chinook, loss of habitat for steelhead may have been somewhat greater than for spring chinook. Natural barriers identified by this review are shown in Table 13.

Table 13. Potential Natural Barriers to Steelhead Migration Upstream of La Grange Dam.

| Feature/Location | Estimated Height | Location |
|-------------------------|-------------------------|--|
| Preston Falls | no data | Boundary of Yosemite National Park, approximately 50 miles upstream of present New Don Pedro Dam |
| North Fork | 12 ft. | Waterfall approximately 1 mile upstream of the mouth of North Fork Tuolumne River |
| South Fork | 25B30 ft. | Waterfall located in the lower portion of the South Fork Tuolumne River |
| Mainstem | no data | Waterfalls just below present Hetch Hetchy Dam on the mainstem, approximately 10 miles above Preston Falls |

(source: Yoshiyama et al. 1996)

Neither the La Grange Dam nor the New Don Pedro Dam are equipped with adult upstream or juvenile downstream passage facilities. The engineering and economic feasibility of providing such passage has not been evaluated. La Grange Dam is 120 feet tall, its reservoir is 2.3 miles long and backs up to New Don Pedro Dam, which is 585 feet tall and its reservoir 26 miles long. Provision of upstream adult passage and downstream adult and juvenile passage at these dams likely is not feasible.

8. The Tuolumne River Should be Excluded from Designation As Critical Habitat for the Central Valley Steelhead ESU

The Districts have asked Stillwater Sciences to address the following questions with regard to the

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proposed critical habitat designation:

1. If steelhead occur in the Tuolumne River, does the river have physical or biological features that are essential to the conservation of the species? If it is essential to the conservation of the species, do these physical or biological features require special management considerations or protection?
2. If steelhead do not occur, is the Tuolumne River essential to the conservation of the species?

Whether or not steelhead occur in the Tuolumne River, there is no reason to conclude that the Tuolumne River contains physical or biological features that are essential to the conservation of the Central Valley steelhead ESU or that it contains physical or biological features that require special management considerations or protection. In addition, in the proposed critical habitat designation, NMFS does not discuss whether (1) the Tuolumne River is essential for the conservation of the Central Valley steelhead ESU, (2) establishing a sustainable steelhead population downstream of La Grange Dam is feasible, and (3) the presence of large numbers of steelhead would adversely impact the Tuolumne River fall chinook salmon population.

The ESA defines critical habitat as “(I) the specific areas within the geographical area occupied by the species, at the time it is listed ... on which is found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed ... upon a determination by the Secretary that such areas are essential for the conservation of the species.” The ESA further states that “[e]xcept in those circumstances determined by the Secretary, critical habitat shall not include the entire geographical area which can be occupied by the threatened or endangered species.” The ESA defines conservation as “the use of all methods and procedures which are necessary to bring an endangered species or threatened species to the point at which the measures required by this Act are no longer necessary” (ESA Section 3 (3)).

NMFS does not discuss whether the Tuolumne River specifically (or other rivers proposed as critical habitat) are essential to the recovery of steelhead or whether each river has physical or biological features that require special management considerations or protection. In the proposed rule, NMFS states that

Based on consideration of the best available information regarding the species' current distribution, NMFS believes that the preferred approach to identifying critical habitat for steelhead is to designate all areas accessible to the species within the range of specified river basins in each ESU. NMFS believes that adopting a more inclusive watershed-based description of critical habitat is appropriate because it (1) recognizes the species' extensive use of diverse habitats and underscores the need to account for all of the habitat types supporting the species' estuarine and freshwater life stages; (2) takes into account the natural variability in habitat uses that makes precise mapping problematic...; and (3) reinforces the important linkage between aquatic areas and adjacent riparian/upslope areas (NMFS 1999, p. 5742).

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Taking this approach, river reaches that are currently accessible to steelhead have been proposed for designation as critical habitat regardless of (1) the historic or current occurrence of steelhead in these reaches, (2) the presence (or absence) of important habitat features, (3) the potential for the proposed critical habitat to support a sustainable steelhead population, and (4) the importance of this habitat in the context of conservation of the ESU. This approach, therefore, seems to be inconsistent with the definition of critical habitat within the ESA.

NMFS' approach does not consider whether the Tuolumne River is essential for the conservation of the Central Valley steelhead ESU or whether establishing a steelhead population downstream of La Grange Dam is feasible. Steelhead historically occurring in the San Joaquin Basin likely used middle and upper watershed areas for spawning and rearing and likely did not rear in the lower river (downstream of the location of La Grange Dam) due to unsuitably high water temperatures in the late summer and early fall. With the La Grange and New Don Pedro Dams in place, anadromous salmonids no longer have access to the middle and upper watershed and are restricted to the 52-mile reach downstream of La Grange Dam. It is unlikely that the Tuolumne River can support a self sustaining steelhead population downstream of La Grange Dam due to lack of suitable rearing and spawning substrate. In the Mokelumne River, lack of suitable rearing substrate is considered to limit steelhead production and make recovery of steelhead difficult or impossible even with the suitable flow conditions (FERC 1993).

In addition, there appears to be no reason to include the lower Tuolumne River, but exclude the San Joaquin River upstream of the Merced River confluence from the proposed critical habitat designation. The San Joaquin River mainstem historically provided important salmonid spawning habitat which was likely suitable for steelhead. Hatton (1940) stated that:

From our standard of comparison, the upper San Joaquin River has the most suitable spawning beds of any stream in the San Joaquin system. The stream is much wider than any of the other streams; the gravel is of notable uniform size; and there is a favorable succession of pools and riffles. Even during the dry year of 1939, most of the suitable areas were adequately covered with water and the water level was satisfactorily constant. Above Friant, however, where the stream enters the canyon, bed rock predominates, and the long, deep pools are connected by short stretches of turbulent water.

Except for flow conditions, habitat conditions on the mainstem San Joaquin River are similar to conditions occurring in the Stanislaus, Tuolumne, and Merced rivers. In that future flow conditions are the management issue most affected by this proposed critical habitat designation, it does not seem that unsuitable flow conditions in the San Joaquin mainstem should exclude this reach from the designation.

Furthermore, flow contributed from the upper San Joaquin River contributes to both water quality and temperature conditions in the mainstem river downstream of the Merced River confluence. The mainstem reach downstream of the Mokelumne River links the three tributaries to the Sacramento-San Joaquin Delta and the ocean and is included in the proposed critical habitat. Failure to address

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inflow from the upper San Joaquin River would limit the ability of future management efforts to improve conditions for steelhead migration in the mainstem San Joaquin River.

The proposed critical habitat designation also does not seem to consider the potential effects that managing the Tuolumne River to conserve steelhead may have on the river's fall chinook salmon population. Since the 1960's, the lower Tuolumne River has been managed by the California Department of Fish and Game for chinook salmon. The Districts initially, then later, working with the TRTAC, have expended considerable effort developing and implementing a program to restore the Tuolumne River fall chinook salmon population. Implementation of this program is in its early stages and the success of implemented measures is currently being evaluated. Many of the measures implemented under this program will also likely improve habitat conditions for steelhead. However, managing this system in an effort to attract and support large numbers of steelhead may be detrimental to the fall chinook salmon recovery effort due to. Major interspecific interactions that should be considered include: (1) competition for spawning gravel and potential for redd superimposition, (2) competition for rearing habitat, (3) predation by steelhead on fall chinook salmon eggs, fry, and juveniles. The degree to which interspecific competition and predation would affect the fall chinook salmon population if large numbers steelhead are attracted to or become established in the Tuolumne River has not been evaluated. Information from the literature regarding these interactions is summarized Appendix G.

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APPENDIX A. STEELHEAD LIFE HISTORY AND HABITAT REQUIREMENTS

Steelhead is the term used for the anadromous life history form of rainbow trout, *Oncorhynchus mykiss*. Steelhead exhibit highly variable life history patterns throughout their range, but are broadly categorized into winter- and summer-run reproductive ecotypes. Winter steelhead, the most widespread reproductive ecotype, become sexually mature in the ocean, enter spawning streams in fall or winter, and spawn a few months later in winter or late spring (Meehan and Bjornn 1991, Behnke 1992). Summer steelhead generally enter fresh water in spring and summer as sexually immature fish, hold over for 8 to 10 months, and spawn the following spring. Adults may return to the ocean after spawning and return to freshwater to spawn in subsequent years. Juveniles remain in fresh water for 2B4 years before emigrating to the ocean. Juvenile emigration typically occurs from April through June. Only winter-run steelhead stocks are currently present in Central Valley streams (McEwan and Jackson 1996). The general timing of winter steelhead life history in California is shown in Table A-1. For comparison, the general timing of fall chinook life history is shown in Table A-2. In the Sacramento River, steelhead generally emigrate as 1-year olds during spring and early summer months. Emigration appears to be more closely associated with size than age, with 6B8 inches being the size of most downstream migrants. Downstream migration in unregulated streams has been correlated with spring freshets (Reynolds et al. 1993).

Table A-1. Central Valley winter steelhead life history timing. See legend below.

| LIFE STAGE | MONTH | | | | | | | | | | | |
|--|-------|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
| Adult Migration ³ | | | | | | | | | | | | |
| Spawning ¹ | | | | | | | | | | | | |
| Adult (kelts) Return to Sea ¹ | | | | | | | | | | | | |
| Incubation ² | | | | | | | | | | | | |
| Emergence | | | | | | | | | | | | |
| Rearing | | | | | | | | | | | | |
| Outmigration ² | | | | | | | | | | | | |

(sources: ¹ Mills and Fisher 1994; ² Reynolds et al. 1993; ³ Hallock et al. 1961, Bailey 1954, as cited in McEwan and Jackson 1996)

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Table A-2. Fall chinook salmon life history in the Lower Tuolumne River.

| LIFE STAGE | MONTH | | | | | | | | | | | |
|---------------------|-------|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
| Adult Migration | | | | | | | | | | | | |
| Adult Holding | | | | | | | | | | | | |
| Spawning | | | | | | | | | | | | |
| Incubation | | | | | | | | | | | | |
| Emergence (fry) | | | | | | | | | | | | |
| Rearing (juvenile) | | | | | | | | | | | | |
| Outmigration Age 0+ | | | | | | | | | | | | |
| Outmigration Age 1+ | | | | | | | | | | | | |

(source: Reavis 1995)

Legend for Tables 1 and 2.

| | |
|--|---------------------------|
| | Span of Light Activity |
| | Span of Moderate Activity |
| | Span of Peak Activity |

UPSTREAM MIGRATION AND SPAWNING

In the Sacramento River, adult winter steelhead migrate upstream during most months of the year, beginning in July, peaking in September, and continuing through February or March (Hallock et al. 1961, Bailey 1954, both as cited in McEwan and Jackson 1996). Spawning occurs primarily from January through March, but may begin as early as late December and may extend through April (Hallock et al. 1961, as cited in McEwan and Jackson 1996). No information on the run timing or life history of steelhead that occurred in the San Joaquin basin is available apart from the observation of 66 adults seen at Dennett Dam on the Tuolumne River from October 1 through November 30 in 1940 and five in late October of 1942 (CDFG unpublished data). In the Central Valley ESU, adult winter steelhead generally return at ages 2 and 3 and range in size from 2 to 12 pounds (0.9-5.4 kg) (Reynolds et al. 1993). Females construct redds in suitable gravels primarily in pool tailouts and heads of riffles. Depths ranging from approximately 7 to 54 inches (18-138 cm) are reported as being used for spawning, with depths of approximately 14 inches (36 cm) being preferred (Moyle et al. 1989, Barnhart 1991). Velocities from 2.0 to 3.8 ft/s (0.6-1.2 m/s) are typically preferred for redd locations (Moyle et al. 1989, Barnhart 1991).

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Aside from cutthroat trout (*O. clarki*), steelhead are the only anadromous species of the genus *Oncorhynchus* that can spawn more than once in fresh water. Individuals that survive the spawning run return to sea between April and June (Mills and Fisher 1996). The frequency of repeat spawning is higher in Oregon and California (Busby et al. 1996) and for females (Ward and Slaney 1988, Meehan and Bjornn 1991, Behnke 1992). In the Sacramento River, California, Hallock (1989) reported that 14 percent of the steelhead were returning to spawn a second time.

Because adult winter steelhead generally do not feed during their upstream migration, delays experienced during migration may affect reproductive success. A minimum depth of about 7 inches (18 cm) is required for adult upstream migration (Thompson 1972, as cited by Barnhart 1986); however, high water velocity and natural or artificial barriers are more likely to affect adult movements than depth (Barnhart 1986, as cited in McEwan and Jackson 1996). Velocities over 8 ft/s (2.4 m/s) may hinder upstream movement (Thompson 1972, as cited in Everest et al. 1985). Steelhead are capable of ascending high barriers under suitable flow conditions and have been observed to make vertical leaps of up to 17 feet (5.1 m) over waterfalls (W. Trush, pers. comm., as cited in Roelofs 1987). Deep pools provide important resting and holding habitat during the upstream migration (Puckett 1975, Roelofs 1983, as cited in Moyle et al. 1989).

Temperature thresholds for the adult migration and spawning life stages are shown in Table A-3. These temperatures, however, are from the general literature and may not represent preferred or suitable temperature ranges for Central Valley steelhead stocks, which may tolerate higher water temperatures than other more northern stocks. No Central Valley-specific temperature evaluations or criteria were identified by our review. For adult migration, temperatures ranging from 46 to 52°F (8 to 11°C) are considered to be preferred (McEwan and Jackson 1996), while temperatures exceeding 70°F (21°C) are stressful (Lantz 1971, as cited in Beschta et al. 1987). Preferred spawning temperatures range from 39-52°F (4-11°C) (McEwan and Jackson 1996, Bell 1973, 1991), with 68°F (20°C) being considered stressful and 72°F (22°C) considered lethal.

Table A-3. Temperature thresholds for steelhead adult migration and spawning.

| Life History Stage | Temperature | Comments | Source |
|--------------------|------------------|----------------------------|---|
| Adult Migration | 46-52°F (8-11°C) | Preferred | McEwan and Jackson 1996 |
| | >70°F (21°C) | stressful (Columbia River) | Lantz 1971, as cited in Beschta et al. 1987 |
| Spawning | 39-49°F (4-9°C) | Preferred | Bell 1973, 1991 |
| | 39-52°F (4-11°C) | Preferred | McEwan and Jackson 1996 |

**EVALUATION OF THE TUOLUMNE RIVER AS POTENTIAL
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| | | | |
|--|-------------------|--------------|-----------|
| | 68°F (20°C) | Stressful | FERC 1993 |
| | >72 °F (>22°C) | Lethal | FERC 1993 |
| | 75°F (24°C) | upper lethal | Bell 1991 |

FRESHWATER REARING AND OUTMIGRATION

Steelhead eggs incubate in the redds for 20-100 days, depending on water temperatures (Shapovalov and Taft 1954, Barnhart 1991). After hatching, alevins (larvae) remain in the gravel for an additional 14-35 days while absorbing their yolk sacs and emerge in spring or early summer (Barnhart 1991).

After emergence, steelhead fry move to shallow water, low velocity habitats such as stream margins and low gradient riffles, and will forage in open areas lacking instream cover (Hartman 1965, Everest et al. 1986, Fontaine 1988). As fry increase in size and their swimming abilities improve in late summer and fall, they increasingly use areas with cover and show a preference for higher velocity, deeper mid-channel areas near the thalweg (Hartman 1965, Everest and Chapman 1972, Fontaine 1988). In general, age 0+ steelhead are found in a wide range of hydraulic conditions (Bisson et al. 1988), appearing to prefer water less than 19.7 in (50 cm) deep with velocities less than 1 ft/s (0.3 m/s) (Everest and Chapman 1972). Age 0+ steelhead have been found to be relatively abundant in backwater pools and in the downstream ends of pools in late summer (Bisson et al. 1988, Fontaine 1988).

Older age classes of juvenile steelhead (age 1+ and older) occupy a wide range of hydraulic conditions. They prefer deeper water during the summer and have been observed to use deep pools near the thalweg that have ample cover as well as higher velocity rapid and cascade habitats (Bisson et al. 1982, Bisson et al. 1988). Age 1+ fish typically feed in pools, especially scour and plunge pools, resting and finding escape cover in the interstices of boulders and boulder-log clusters (Fontaine 1988, Bisson et al. 1988). During summer, steelhead parr appear to prefer habitats with rocky substrates, overhead cover, and low light intensities (Hartman 1965, Facchin and Slaney 1977, Ward and Slaney 1979, Fausch 1993). Age 1+ steelhead appear to avoid secondary channels and dammed pools, glides, and low gradient riffles with mean depths less than 7.9 in (20 cm) (Fontaine 1988, Bisson et al. 1988, Dambacher 1991).

During the winter period of inactivity, steelhead prefer pool habitats, especially low velocity, deeper pools, including backwater and dammed pools, with large rocky substrate or woody debris for cover (Hartman 1965, Swales et al. 1986, Raleigh et al. 1984, Fontaine 1988). During periods of low temperatures and high flows associated with the winter months, age 0+ steelhead tend to reside in rubble substrates (4-10 inch diameter [10B25 cm]) in shallow, low velocity areas near the stream margin (Bustard and Narver 1975). Age 0+ steelhead often occupy water less than 6 in (15 cm) deep and are rare in water deeper than 24 in (60 cm). Age 1+ steelhead use interstices between assemblages of large boulders [>39 in (100 cm) diameter], logs, and/or rootwads as winter cover (Bustard and Narver 1975, Everest et al. 1986). Age 1+ steelhead

prefer water deeper than 17 in (45 cm). Age 1+ fish typically stay within the summer low flow area of the streambed, while age 0+ fish frequently overwinter beyond the summer low flow perimeter along the stream margins (Everest et al. 1986).

As steelhead grow larger, they tend to prefer microhabitats (or "focal points") with deeper water and higher velocity, attempting to find areas with an optimal balance of food supply and energy expenditure, such as velocity refuge positions associated with boulders or other large roughness elements close to fast current areas with high drift rates (Everest and Chapman 1972, Bisson et al. 1988, Fausch 1993). Age 1+ steelhead prefer high velocity pool heads (where food resources are abundant) and pool tails (which provide optimal feeding conditions in summer due to lower energy expenditure requirements than the more turbulent pool heads) (Reedy 1995). Fast, deep water, in addition to optimizing feeding versus energy expenditure, provides greater protection from avian and terrestrial predators (Everest and Chapman 1972).

Most steelhead south of Alaska and British Columbia smolt after a period of two years in fresh water and spend two years in the ocean before returning to their natal streams to spawn. Populations in Oregon and California, however, have higher frequencies of adults returning after only one year in the ocean (Busby et al. 1996). In the Sacramento River, the most common life history pattern is for two years in freshwater prior to smolting and one year in the ocean. The second most common pattern is for two years in freshwater prior to smolting and two years in the ocean.

Temperature thresholds for the incubation, rearing, and outmigration life history stages are shown in Table A-4. Information available in the literature indicates preferred incubation temperatures ranging from 48 to 52°F (9 to 11°C) (McEwan and Jackson 1996, FERC 1993), preferred rearing temperatures from 48 to 58°F (9 to 20°C), and preferred outmigration temperatures of <57°F (<13°C). Of this information, however, only Myrick (1998) provides the only assessment of temperature tolerances specifically for Central Valley steelhead. These experiments used steelhead that were reared at the Mokelumne River State Fish Hatchery from eggs were collected at the Nimbus Fish Hatchery (American River). These experiments indicate that Central Valley steelhead prefer higher temperature ranges than those reported in the literature for other stocks, with preferred rearing temperatures ranging from 62.6 to 68°F (17 to 20°C) and a maximum temperature tolerated (lethal critical thermal maximum) of 80°F (27°C).

Table A-4. Temperature thresholds for incubation, rearing, and outmigration of steelhead.

| Life History Stage | Temperature °F (°C) | Comments | Source |
|--------------------|---------------------|--------------------------------------|--------------------------------------|
| Incubation | 50°F (10°C) | preferred (hatching) | Bell 1991 |
| | 48-52°F (9-11°C) | preferred Aincubation and emergence@ | McEwan and Jackson 1996 FERC 1993 |

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| | | | |
|-----------------------|-------------------------|--|---|
| | >55°F (>12.8°C) | Stressful | FERC 1993 |
| | 60°F (15.6°C) | Lethal | FERC 1993 |
| Juvenile Rearing | 48-52°F (9- 1°C) | preferred Afry and juvenile rearing@ | McEwan and Jackson 1996 |
| | 55-5°F (12.8- 8.3°C) | optimal | FERC 1993 |
| | 62.6-8°F (17- 0°C) | preferred A Central Valley Steelhead@ | Myrick (1998) p. 134 |
| | 50-9°F (10- 5°C) | preferred | Moyle et al. 1995 |
| | 68°F (20°C) | sustained upper limit | Moyle et al. 1995 |
| | 77°F (25°C) | lethal | FERC 1993 |
| | 80°F (27°C) | lethal critical thermal maximum A Central Valley Steelhead@ A absolute maximum temperature tolerated@ | Myrick (1998) |
| Smolt Outmigration | <57°F (14°C) | preferred | McEwan and Jackson 1996 |
| | >55°F (13°C) | stressful (inhibit gill ATPase activity) | Zaugg and Wagneer 1973, Adams et al., 1975, both as cited in ODEQ 1995 |

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APPENDIX B.
TUOLUMNE RIVER WATER TEMPERATURES RECORDED AT THE DISTRICTS'
MONITORING STATIONS B WATER YEARS 1987-998

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**EVALUATION OF THE TUOLUMNE RIVER AS POTENTIAL
CRITICAL HABITAT FOR STEELHEAD**

**APPENDIX C.
MONITORING ACTIVITIES WITH POTENTIAL TO
DETECT PRESENCE OF STEELHEAD AND RAINBOW TROUT**

| Method | Site | River Mile | Year(s) Sampled |
|-------------------------------|---|-----------------------|----------------------------------|
| Fyke Net | Turlock Lake State Recreation Area | 42.4 | 1973, 74, 77, 1980-3, 86 |
| | Reed Sand and Gravel | 34.0 | 1980, 82 |
| | Putnam Sand and Gravel | 30.6 | 1973, 74, 77 |
| | Fox Grove | 26.2 | 1980 |
| | McCleskey Farm | 6.2 | 1973, 74, 77, 80, 82 |
| Seine | Old La Grange Bridge | 50.5 | 1983-86 |
| | Basso Bridge | 48.0 | 1983 |
| | Turlock Lake State Recreation Area | 42.4 | 1983-86 |
| | Reed Sand and Gravel | 34.0 | 1984-85 |
| | Hickman Bridge | 31.6 | 1984-85 |
| | Legion Park | 17.2 | 1983-86 |
| | Riverdale Park | 12.3 | 1985 |
| | McCleskey Farm | 6.2 | 1984-85 |
| | Shiloh Bridge | 3.4 | 1983-86 |
| Rotary Screw Trap | Shiloh Road | 3.6 | 1995-1998 |
| | Grayson River Ranch | 5.1 | 1999 |
| | TLSRA | 42.0 | 1998 |
| | 7/11 Gravel Mine | 38.5 | 1998-1999 |
| | Fox Grove | 25.0 | 1998 |
| | Charles Road | 24.7 | 1998 |
| | Hughson | 23.7 | 1999 |
| Direct Observation | Various locations downstream of La Grange Dam | N/A | 1981, 1982, 1984-1986, 1992-1996 |

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| | | | |
|----------------|-----------------------|---------|------|
| Electrofishing | Riffle 2 | 49.9 | 1990 |
| | Unknown | | 1997 |
| | Charles Road to SRP 7 | 24.5-29 | 1998 |

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**EVALUATION OF THE TUOLUMNE RIVER AS POTENTIAL
CRITICAL HABITAT FOR STEELHEAD**

**Appendix D. RAINBOW TROUT OBSERVATIONS IN THE TUOLUMNE RIVER,
1981-1999**

| Method | Location | River Mile | Date | Number Observed | Fork Length (mm) | Estimated Life Stage | |
|------------------|----------------------|------------|------------------|-----------------|--------------------|----------------------|-----|
| | | | | | | 0+ | 1+ |
| 1981 | | | | | | | |
| Snorkel | La Grange Powerhouse | 51.9 | 12 July 1981 | N/A | N/A | N/A | N/A |
| 1982 | | | | | | | |
| Snorkel | R5 | 48.0 | 1 August 1982 | 2 | 350 | | X |
| 1983 | | | | | | | |
| Seine (CDFG) | Old La Grange Bridge | 50.5 | 15 April 1983 | 1 | 39 | X | |
| Seine (CDFG) | Old La Grange Bridge | 50.5 | 6 May 1983 | 1 | 60 | X | |
| Seine (CDFG) | Old La Grange Bridge | 50.5 | 9 June 1983 | 1 | 41 | X | |
| 1984 | | | | | | | |
| Seine (CDFG) | Old La Grange Bridge | 50.5 | 16 February 1984 | 4 | N/A | N/A | N/A |
| Stranding Survey | R4B | 48.4 | 16 March 1984 | 4 | 25-30 | X | |
| Seine (CDFG) | Old La Grange Bridge | 50.5 | 1 March 1984 | 2 | N/A | N/A | N/A |
| Snorkel Survey | R4BBR5 | 48.0B48.4 | 11 April 1984 | 12 | 150-300 | | X |
| Snorkel Survey | RA7 | 50.7 | 10 August 1984 | 27 | 80-150 | X | |
| 1985 | | | | | | | |
| Snorkel Survey | R4BBR5 | 48.0B48.4 | 21 March 1985 | 2 | 300, 350 | | X |
| 1986 | | | | | | | |
| Seine | R4B | 48.4 | 23 April 1986 | 1 | 37 | X | |
| Seine | Old La Grange Bridge | 50.5 | 12 May 1986 | 1 | 29 | X | |
| Seine | Old La Grange Bridge | 50.5 | 19 May 1986 | 1 | 26 | X | |
| Seine | Old La Grange Bridge | 50.5 | 30 May 1986 | 1 | 29 | X | |
| Seine | R4B | 48.4 | 30 May 1986 | 1 | 30 | X | |
| Seine | Old La Grange Bridge | 50.5 | 11 June 1986 | 2 | 36, 54 | X | |
| Seine | R4B | 48.4 | 11 June 1986 | 2 | 74, 67 | X | |
| Seine | R4B | 48.4 | 19 June 1986 | 1 | 80 | X | |
| Seine | Old La Grange Bridge | 50.5 | 26 June 1986 | 5 | 46, 66, 79, 58, 67 | X | |
| Snorkel Survey | R4B | 48.4 | 1 July 1986 | 5 | 40-80 | X | |

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CRITICAL HABITAT FOR STEELHEAD**

| | | | | | | | |
|------------------------|-----------------------|---------------|-----------------------|-----|-----------------------|---------|--------|
| Snorkel Survey | RA3BR5 | 48.0B51. 6 | 14 August 1986 | 65 | 100-350 | | X |
| 1987 | | | | | | | |
| Seine | R4B | 48.4 | 26 February 1987 | 1 | 28 | X | |
| Seine | R4B | 48.4 | 4 March 1987 | 1 | 33 | X | |
| Angler | R4B | 48.4 | 4 March 1987 | 1 | 332 | | X |
| Seine | Old La Grange Bridge | 50.5 | 13 March 1987 | N/A | YOY (in tributary) | X | |
| Seine | Old La Grange Bridge | 50.5 | 26 March 1987 | 1 | 26 | X | |
| Mark-Recapture | R4B | 48.4 | 14 May 1987 | 1 | 88 | X | |
| Seine | R5 | 48.0 | 20 May 1987 | 2 | 59, 32 | X | |
| Seine | Old La Grange Bridge | 50.5 | 20 May 1987 | 3 | 31, 30, 29 | X | |
| Stranding Survey | RA4 | 51.6 | 1 June 1987 | 7 | 29-35 | X | |
| Stranding Survey | R5 | 48.0 | 2 June 1987 | 5 | 62-92 | X | |
| Seine | Old La Grange Bridge | 50.5 | 3 June 1987 | 2 | 33, 37 | X | |
| 1988 | | | | | | | |
| Seine | Old La Grange Bridge | 50.5 | 16 May 1988 | 1 | 34 | X | |
| 1990 | | | | | | | |
| Electrofishing | R2 | 49.9 | 30 May 1990 | 1 | 73 | X | |
| 1992 | | | | | | | |
| Snorkel Survey | RA3 | 51.6 | 9 June 1992 | 1 | 150 | | X? |
| 1995 | | | | | | | |
| Snorkel Survey | RA7, R5 | 48.0 | 30 November 1995 | 3 | 220-250 | | X |
| 1996 | | | | | | | |
| Snorkel Survey (CDFG) | RA7BR5 | 48.0B50. 7 | July 1996 | 380 | | x = 316 | x = 64 |
| Snorkel Survey | R7 | 46.9 | 3 July 1996 | 4 | 90-110 | X | |
| 1997 | | | | | | | |
| Seine | Tuolumne River Resort | 42.2 | 12 March 1997 | 1 | 35 | X | |
| Spawning Survey (CDFG) | Tuolumne River Resort | 42.2 | October-December 1997 | 3 | 410, 480, ? | | X |
| 1998 | | | | | | | |
| Seine | R4B | 48.4 | 22 April 1998 | 1 | 28 | X | |
| Spawning Survey (CDFG) | R4B | 48.4 | October-December 1998 | ~10 | ~250 average | | X |
| 1999 | | | | | | | |
| Rotary Screw Trap | 7/11 | 38.5 | 21 January 1999 | 1 | 198 | | X |

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| | | | | | | | |
|-------|-----------------------|------|------------------|---|----|---|--|
| Seine | Tuolumne River Resort | 42.2 | 24 February 1999 | 1 | 25 | X | |
| Seine | R5 | 48.0 | 8 April 1999 | 1 | 27 | X | |

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APPENDIX E.
**EFFORTS TO IMPROVE SALMONID HABITAT CONDITIONS IN THE TUOLUMNE
RIVER**

Projects Currently Being Implemented

SRPs 9 and 10 Channel and Floodplain Reconstruction

Located 15 miles east of Modesto and immediately downstream of the Geer Road bridge, SRPs 9 and 10 extend from RM 25.2 to RM 25.9. These SRPs are large pits that were created by extensive in-channel aggregate mining, which began as early as 1937. SRP 9 is 400 feet wide and 6 to 19 feet deep, and SRP 10 is 400 feet wide and 10 to 36 feet deep pit. These SRPs have not appreciably filled since they were created due to (1) upstream SRPs, (2) the large size of these pits, (3) interception of sediment supply by upstream dams, and (4) reduced magnitude, duration, and frequency of sediment-transporting flows.

These in-channel aggregate extraction pits have a significant impact on chinook salmon production in the Tuolumne River by increasing habitat suitability and abundance of species that prey on juvenile salmonids (largemouth and smallmouth bass), reducing spawning and rearing habitat for salmon, and by reducing smolt outmigration success (TID/MID 1992). Nearly all salmon spawning in the Tuolumne River occurs upstream of SRPs 9 and 10, so most juveniles and smolts must migrate through these pits and risk predation.

The projects will reconstruct an appropriately scaled bankfull channel and floodplain and re-establish native riparian habitat in the SRPs 9 and 10 reach. The objectives of the SRPs 9 and 10 projects are to:

- reduce salmon predation by reducing predator habitat;
- restore and increase salmon habitat;
- rebuild a natural channel geometry scaled to current channel-forming flows; and
- restore and increase native riparian plant communities, establishing each species at appropriate surface elevations inundated by the contemporary hydrologic regime.

Reconstruction of SRP 9 has been funded by the USFWS through the AFRP and CalFed and is being implemented by the Agencies. It is currently undergoing design and environmental review. Assessment of baseline geomorphic and ecological conditions at these sites began in 1998, as required by the monitoring and adaptive management program.

Gravel Mining Reach Channel and Floodplain Reconstruction B Phase I

The six mile long Gravel Mining Reach extends from near Roberts Ferry Road at RM 40.3 to the downstream extent of the contemporary aggregate extraction operations at the George Reed site at RM 34.3. Within this reach, the river has been extensively mined, both in the channel and on adjacent floodplains and terraces. As a result, the river channel in the project reach is bounded by 11 mining pits and one captured settling pond on the left (south) bank and three settling ponds on the right (north) bank. On the left bank, pit embankments constitute 17,500 feet (55 percent)

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of the total river bank length. On the right bank, pit embankments constitute 735 feet (2 percent) of the total river bank length. Throughout the reach, the embankments confine the width of the channel and riparian corridor. A portion of the channel has also been mined. The Gravel Mining Reach Restoration project will be implemented in four phases, each of which is considered to be an individual project. Each phase will require about one year to complete.

The Gravel Mining Reach Restoration project will set back gravel pit embankments (widening the floodway to 500 feet), construct an appropriately scaled bankfull channel and floodplain within the widened floodway, and establish native riparian vegetation on the newly constructed floodplain. Vegetation would be established at elevations appropriate to support inundation and successional processes under the existing flow conditions.

The objectives of the Gravel Mining Reach projects are to:

- restore a floodway width that will convey floods of up to 15,000 cfs;
- improve salmon spawning and rearing habitats by restoring an alternate bar (pool-riffle) morphology, restoring spawning habitat within the meandering channel, and filling in-channel mining pits;
- prevent salmon mortality that results from connection between the Tuolumne River and off-channel mining pits;
- restore native riparian communities on appropriate geomorphic surfaces (i.e., active channel, floodplains, terraces) within the restored floodway;
- restore habitats for other native species (e.g., egrets, ospreys, herons);
- allow the channel to migrate within the restored floodway to improve and maintain riparian and salmonid habitats;
- remove the floodway Abottleneck created by inadequate berms (e.g., berm failure above a certain discharge threshold); and
- improve flood protection for aggregate extraction operations, bridges, and other human structures.

All phases are currently undergoing environmental review. Implementation of all phases is scheduled over a four-year period but is dependent on the availability of additional funds. Phase I of the projects has been funded by CalFed and AFRP and is being implemented by the Agencies. Assessment of baseline biological conditions at this site began in the summer of 1998, as required by the adaptive management and monitoring program.

Coarse Sediment Augmentation

CDFG is implementing the initial phase of a two-phase project to increase the supply of coarse sediment to the lower Tuolumne River by introducing clean gravel to the channel between La Grange Dam (RM 52.2) and Basso Bridge (RM 47.5). The gravel mixture will be suitable for chinook salmon spawning and will be mobilized under the river's current flow regime, mimicking natural coarse sediment transport processes. Phase One of this project, introducing 10,000 yds³ of gravel, has been funded by CalFed. CDFG has submitted a Phase Two proposal to CalFed. The TRTAC has also submitted a proposal to CalFed to develop and implement a sediment management plan for the lower Tuolumne River (see below).

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Basso Bridge Riparian and Floodplain Acquisition

CDFG has received funding from CalFed to purchase 41.6 acres of property bordering the Tuolumne River. The purpose of this acquisition is to (1) acquire and protect valley foothill riparian habitat along an important spawning reach of the Tuolumne River and (2) acquire an in-holding that will result in contiguous public ownership on one bank of three miles of riparian habitat and salmon spawning habitat. The properties harbor riparian vegetation such as valley oak, willow, and cottonwood. The river channel to which these properties are adjacent provides prime chinook salmon spawning habitat. The three parcels were the only remaining private properties on the south bank of the Tuolumne River between La Grange Road (RM 50) and Basso Bridge (RM 47.5) and provide a critical link between more than 350 acres of County-owned property to the west and more than 145 acres of County-owned property to the east (part of the La Grange Regional Park). CalFed and the California Wildlife Conservation Board are currently proceeding with contract requirements.

Grayson River Ranch Easement Acquisition and Riparian Restoration

The NRCS has acquired funds to purchase a conservation easement on a 140-acre property known as the Grayson River Ranch. This property, which extends from RM 5.1 to RM 6.3, was formerly a riparian forest. Much of this forest is shown in 1937 aerial photographs, although approximately one third of the property had already been cleared by that time. The property is isolated from the river by a privately owned levee, which was breached during the January 1997 flood. The downstream portion of the property is inundated under even moderate flow conditions. The NRCS has reserved \$254,700 (the maximum funding allowable under the Wetlands Reserve Program) toward this project and has obtained \$732,000 from CalFed.

Projects For Which Funding is Currently Being Sought

SRP 10 Channel and Floodplain Reconstruction

Reconstruction of SRPs 9 and 10 is described in Section 4.1 above. Funding for completion of SRP 10 has been requested in the 1999 CALFED funding cycle.

Gravel Mining Reach Channel and Floodplain Reconstruction B Phase II

Funding for Phase II of the channel and floodplain reconstruction project in the gravel mining reach, described in Section 4.1 above, has been sought in the 1999 CALFED funding cycle. Funding sources for Phases III and IV have not been identified yet.

Development and Implementation of a Sediment Management Plan

The purpose of this project is to develop and implement a comprehensive sediment management plan for the 23 mile alluvial reach of the Tuolumne River below La Grange Dam (RM 52.2B29). A general strategy for sediment management was presented in the *Draft Tuolumne River*

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Corridor Habitat Restoration Plan. Four critical tasks for restoring and maintaining a balanced sediment budget in the gravel-bedded reach were identified: (1) greatly increase coarse sediment storage in the channel with a large Atransfusion@ of coarse sediment to provide alluvial deposits immediately available for chinook salmon spawning and for eventual downstream transport and redeposition, (2) maintain this restored coarse sediment storage by periodic augmentation of coarse sediment supply equal to the rate of downstream sediment transport, (3) implement remedial actions to prevent further extensive fine sediment input into the Tuolumne River from Gasburg Creek (located near the upstream end of the spawning reaches) and other sources, and (4) implement actions to reduce fine sediment storage in the mainstem Tuolumne River.

Bobcat Flat Property Acquisition

Friends of the Tuolumne is seeking to acquire and restore riparian habitat on A Bobcat Flat@ Cabout 250 acres of the Tuolumne River floodplain at approximate river mile 42.4 to 44.6 (right bank). Portions of this property that are not currently grazed show high potential for restoration of important riparian habitat. Additional expected benefits include restoration of habitat for riparian birds, including neotropical migrants, and improvement of floodplain and channel functions.

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APPENDIX F.
MODELED FLOWS REQUIRED TO PROVIDE WATER TEMPERATURE $\leq 60^{\circ}\text{F}$ FOR
1978-1988 METEOROLOGICAL AND WATER YEAR CONDITIONS

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APPENDIX G.
POTENTIAL INTERSPECIFIC INTERACTIONS BETWEEN STEELHEAD AND FALL
CHINOOK

Competition for Spawning Gravel and Redd Superimposition

In the Tuolumne River, redd superimposition is believed to be a major factor limiting fall chinook production (TID/MID 1992). Establishment of a steelhead population in the lower river could result in superimposition of fall chinook salmon redds if the two species choose similar size gravels for spawning. Where winter steelhead and fall chinook salmon occur in the same stream, competition for spawning areas is often reduced by spatial and temporal segregation. Steelhead are physically more capable of ascending steeper reaches and of surmounting higher obstacles than fall chinook salmon and will often use tributary and upper watershed habitat for spawning where it is available (Briggs 1953, Reavis 1995), while fall chinook salmon often prefer to spawn in the mainstem or lower portions of large tributaries (Yoshiyama et al. 1996). In smaller streams or where access to tributaries or upper watershed areas is unavailable, the two species may spawn in the same reaches of a stream; however, the timing of spawning often differs, with fall chinook salmon arriving to spawn a few months earlier than steelhead. Further habitat segregation may occur through selection of suitable spawning sites if significant size differences exist between the size of adult spawners of the two species. Fall chinook salmon are usually larger than winter steelhead and may thus spawn in areas with larger size gravels than steelhead (Huntington 1985). Where the two species overlap in spawning distribution and where preference is shown for similar size gravel for spawning, there would be a risk of chinook salmon redds being superimposed on by the later-spawning steelhead during the chinook salmon egg incubation and alevin development period (Coots 1957). Because both species would be restricted to spawning in a relatively small area downstream of La Grange Dam, the likelihood that the two species would overlap in their preference for spawning gravels is increased. Superimposition of chinook salmon redds by steelhead may therefore be more likely to occur in the Tuolumne River.

Competition for Rearing Habitat

Both fall chinook salmon and steelhead use similar habitats as fry following emergence, with shallow low velocity habitats in stream margins being preferred (Everest and Chapman 1972, Reedy 1995). As they grow in size, both species venture into habitats with deeper water and higher velocities (Shapovalov and Taft 1954, Everest and Chapman 1972). Depending on differences in the timing of emergence, competition for fry habitat may therefore occur to some degree. Earlier emergence of chinook salmon can reduce such competition because fall chinook fry may have moved to deeper water by the time of steelhead fry emergence (Everest and Chapman 1972).

In the Tuolumne River, competition for rearing habitat would be expected to occur primarily from February through May, between the periods of fry emergence and smolt outmigration of fall chinook salmon. A small portion of the chinook population is known to occasionally

oversummer in the Tuolumne River in some years, outmigrating at age 1+ in the fall and winter. Competition between juvenile steelhead and chinook salmon could therefore potentially occur year round, but to a lesser degree than during the spring. The establishment of a steelhead or rainbow trout population in the lower Tuolumne could potentially reduce rearing area for juvenile chinook salmon where the two species habitat preferences overlap; however spatial and temporal habitat segregation appears to reduce the effects of such competition in many areas where the two species coexist (Everest and Chapman 1972, Reedy 1995).

Predation by Steelhead on Eggs, Fry, and Juvenile Chinook Salmon

Egg predation by steelhead may not significantly affect fall chinook salmon. Juvenile steelhead may feed on salmonid eggs, most of which are assumed to have been dislodged from the gravels or may be taken during spawning. Predation on fry and juveniles, however, may be more significant.

Predation by juvenile steelhead on other juvenile salmonids has been documented to occur in some instances. Coots (1957) notes that juvenile chinook salmon have been recovered from the stomachs of juvenile steelhead collected from Fall Creek, a tributary of the Klamath River, California, and states that predation on chinook fry and fingerlings by juvenile steelhead may be an important factor, but does not give any further details. Meacham and Clark (1979) mention rainbow trout as potential predators of juvenile salmon, but do not offer any data or citations to support the statement. Shapovalov and Taft (1954) mention that A...from scattered data it is known that it is not uncommon for stream steelhead to prey upon [other steelhead and coho salmon]. The numbers and sizes consumed depend upon the size and composition of the populations of both species, the time of year, the abundance of other food, and other factors. Specific instances of steelhead predation noted by Shapovalov and Taft (1954) included a 165 mm steelhead taken in a migrant trap that contained 4 steelhead fry ranging 47-60 mm in its stomach. A six-inch steelhead smolt taken at Benbow Dam on the South Fork of the Eel River, California contained nine fry in its stomach, four of which were coho salmon from one to one and one-fourth inches long, and five unidentifiable fish.

Other studies have indicated that fish comprise only a small portion of the diet of juvenile steelhead. Idyll (1942, as cited in Shapovalov and Taft 1954) found salmonids formed only a very small portion of the diet of steelhead measuring 254-508 mm (10-12 inches) long from the Cowichan River, British Columbia. Chapman and Quistorff (1938) examined the stomach contents of 819 age 0+ to age 2+ steelhead collected during the spring, summer, and fall from the Wenatchee River basin (a tributary to the north central Columbia River in Washington) and found that their diet consisted primarily of insects despite the availability of abundant dace, suckers, shiners, and steelhead fry on which to feed. They did, however, state that resident rainbow trout may be more predatory on the salmon due to their larger size.

Adult winter steelhead (with the exception of half pounder steelhead found in the Klamath and Eel rivers) are not believed to feed to any great extent during their freshwater spawning migration (Shapovalov and Taft 1954, etc.). Half pounder steelhead are known to feed while

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returning to spawn, but fish are apparently not included in their diet (Barnhart 1991). Adult summer steelhead are known to feed while in freshwater, however, in a study by Vander Haegen et al. (1998) of 1,041 summer steelhead stomachs collected from June through October, only two (0.2 percent) contained fish, which consisted of the remains of four salmonids.

In the Tuolumne River, predation on fry and juvenile chinook salmon by steelhead could occur during the months between emergence and smolt outmigration from February to May. Juvenile steelhead in the Sacramento River generally outmigrate at 6-8 inches (152-203 mm) in length (Reynolds et al. 1993). Some predation of chinook salmon fry by rearing steelhead could potentially occur in the Tuolumne River, depending on the overlap in distribution between chinook salmon fry and these older age classes of juvenile steelhead. Chinook and steelhead fry would likely be most vulnerable to predation during their emergence and dispersal to suitable fry rearing habitat or during periods of fry outmigration. Habitats used by fry and age 1+ steelhead would not be expected to overlap to a great extent, however, because juvenile steelhead age 1+ and 2+ prefer higher velocity, deeper habitats and fry prefer stream margins and other low velocity habitats. Once juvenile chinook move into the deeper water of pools, they may be susceptible to predation by age 2+ steelhead.

Management of the river to establish a reproducing steelhead population in the lower Tuolumne River may result in an increased number of resident rainbow trout in the river as well. Predation by large resident rainbow trout would likely pose a greater risk to chinook salmon than predation by juvenile steelhead. Rainbow trout in Central Valley streams often grow to large sizes capable of preying on fry and juvenile chinook salmon and may share similar habitats with rearing chinook salmon.

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